TM 5-692

WAR DEPARTMENT TECHNICAL MANUAL

FIRE DEPARTMENT TECHNIQUES

WAR DEPARTMENT • APRIL 1946

TECHNICAL MANUAL

FIRE DEPARTMENT TECHNIQUES

CHANGES No. 1

WAR DEPARTMENT
WASHINGTON 25, D. C., 5 September 1946

TM 5-692, 23 April 1946, is changed as follows:

Change legend, figure 43, page 35, to read "Accordian load."

Change legend, figure 44, page 36, to read "Horseshoe load."

21. Loads

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b. (Superseded) ACCORDIAN LOAD (fig. 43). Although the accordian load is easy to place in the hose bed and is generally used, all the bends are sharp, tending to cramp the hose's rubber lining. The load is started with the hose end in the right front corner, with the hose folded back and forth across the hose bed. Every other bend is made a few inches shorter than the preceding one so bends are less sharp and paying out is easier. When completing the layer at the side of the bed, the last length is gradually raised from front to rear until at the rear it is on top of the first layer. As each layer is completed, the remaining space becomes narrower than the diameter of the coupling. If the hose is placed in this space so the coupling must turn around in paying out, it will jam. To avoid this, a reverse bend (Dutchman) is made at the coupling, as shown. This procedure is also used to avoid placing two couplings in one layer immediately opposite each other.

c. (Superseded) HORSESHOE LOAD (fig. 44). The horseshoe load (U-load) most nearly meets the above requirements. It is started in the right corner of the bed. Hose is laid around the inside of the bed with alternate rear folds made shorter so bends do not crowd. Rear bends on the half of the bed around which hose for the next layer passes are 2 inches shorter so the completed load is neat.

* * * * * * *

[AG 300.7 (21 Aug 46)]

BY ORDER OF THE SECRETARY OF WAR:

DWIGHT D. EISENHOWER
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL
Major General
The Adjutant General

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For explanation of distribution formula, see FM 21-6.

AGO 535A—Sept. 705557°—46

U. S. GOVERNMENT PRINTING OFFICE: 1946

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United States Government Printing Office

Washington: 1946

WAR DEPARTMENT
Washington 25, D. C., 23 April, 1946

TM 5-692, Fire Department Techniques, is published for the information and guidance of all concerned.

[AG 300.7 (5 Mar 46)]

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Refer to FM 21-6 for explanation of distribution formula.

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CONTENTS

SECTION I
INTRODUCTION

1. Purpose and Scope

This Technical Manual is a guide to techniques used in fire fighting. It outlines principles of selecting fire department personnel and presents correct procedure for using equipment, including hand extinguishers, axes, pike poles, ropes, ladders, nozzles, and hose. Recommended methods of salvaging property from fire loss or damage and producing adequate hose streams are also described. The discussion of fires in unventilated buildings includes an explanation of the combustion process, hazards involved, precautions to be taken, and rescue procedure. (See fig. 1.)

2. Responsibility

The fire chief is responsible for administration and operation of the fire department; he is also responsible for establishing and conducting an adequate training course for personnel under his direction. To insure physical fitness and familiarity with equipment and procedures, this training program must be continuous.

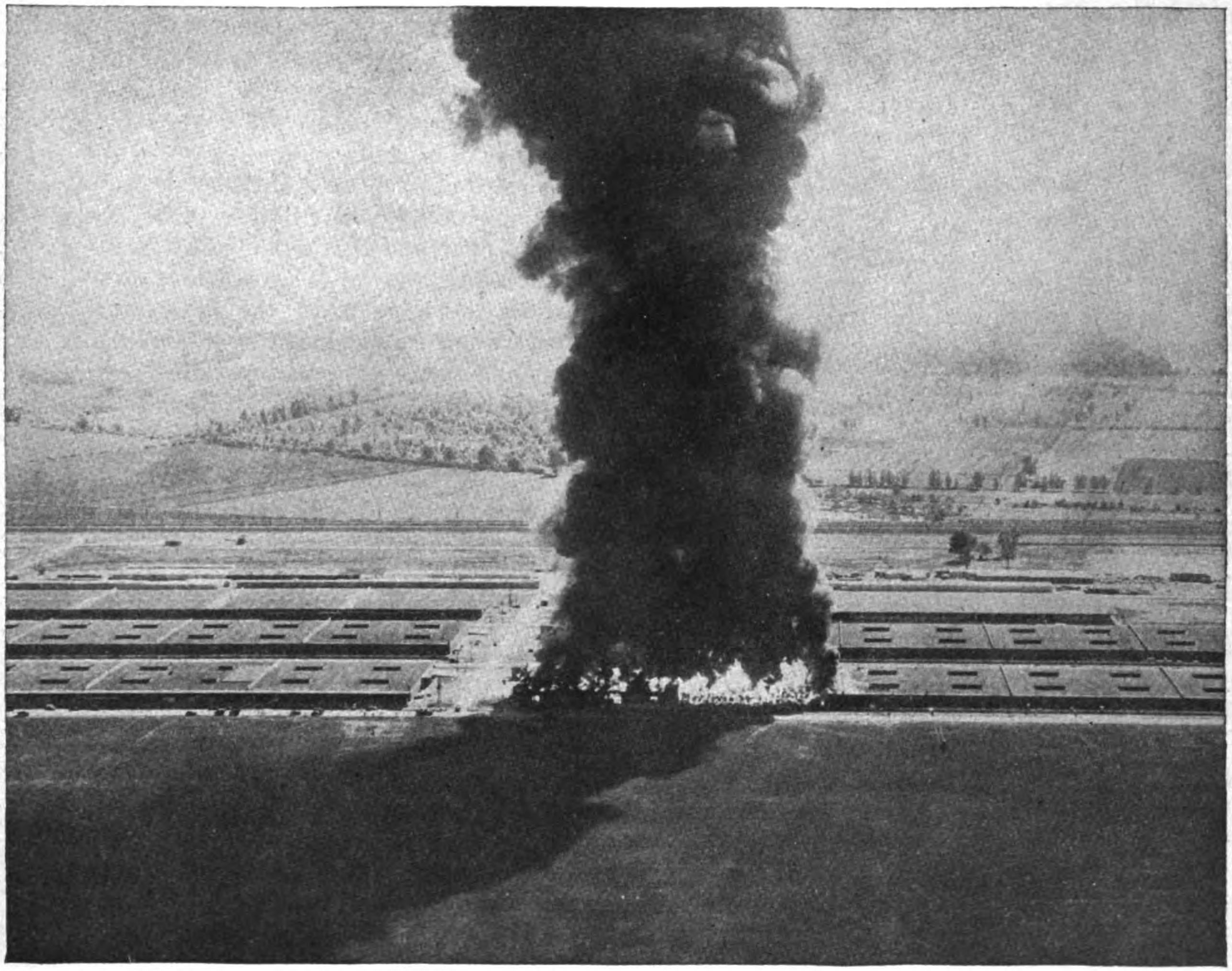


Figure 1. Possible result of inadequate fire-control measures.

SECTION II

FIRE DEPARTMENT PERSONNEL

3. Skilled Fire Fighters

If untrained beginners are to be developed into skilled fire fighters, careful indoctrination, thorough instruction, and intensive practice in various mechanical skills are required. Several important factors in the development of a skilled fire fighter are discussed below.

a. MORALE. The beginner must have a will to serve others, realize the importance of his job, and be eager for the necessary study and practice. He must be impressed by the fact that protection of life and property depend on his knowledge, stamina, and courage. He must understand that his work consists of long tedious days of preparatory training for a few hours of emergency when he suddenly becomes one of the most important men on the post. When first employed, he should be indoctrinated in customs of the fire service and the history of fire fighting.

b. DISCIPLINE. During a fire emergency, units of command must be maintained and all orders from superiors must be carried out promptly, without question. Discipline during an emergency is developed only through habitual obedience to orders of daily routine. The following rules should be applied at all fire stations:

(1) Regulate personal conduct both on and off duty to bring credit to the fire department.

(2) Obey without question or delay all orders of superior fire department officers.

(3) Keep in peak of physical condition

(4) Maintain station and equipment scrupulously clean and in proper operating condition.

(5) Carry each assigned task to successful completion.

(6) Abide by all rules and regulations of both post and fire department.

(7) Discuss nothing of military value with persons not directly concerned.

c. FUNDAMENTAL PRINCIPLES OF EXTINGUISHMENT. Because certain laws of nature apply to all processes of burning, fire fighters are taught the fundamental principles of combustion so they can attack fires scientifically. Practice in the use of hand extinguishers is excellent for training beginners. Any good texts and films on fire fighting may be used for supplementary information.

d. POST LAYOUT. Although fire fighters can learn the location of the post's buildings by studying maps, personal tours of the post are more effective. Assigning fire fighters to accompany building inspectors on their rounds is good practice because it acquaints them with building location, contents, type of occupancy, and specific hazards. All factors affecting rescue or extinguishment such as fire exits, canals, wells, and hydrants should be thoroughly studied. Complete familiarity with the physical lay-out of the post saves times when a fire emergency arises.

e. HOSE AND NOZZLE PRACTICE. Fire fighters must know every type of hose and nozzle used on the post. Various combinations should be used in practice to demonstrate their limiting features. Potentialities and limitations of nozzle and hose, including booster lines and 1½- and 2½-inch lines, should be studied. Repeating hose drills regularly helps fire fighters acquire automatic habits in bringing hose streams to bear on a fire. Individual tasks in hose and nozzle manipulation are simple, but constant practice is needed to enable men to perform the tasks under the stress of an emergency. Standard hand signals, in accordance with TM 5-315 should be practiced during drill periods. Manufacturer's instructions, Army publications, and firemanship texts provide information for studying hose and nozzle practices.

f. EQUIPMENT. Efficient fire fighters must know design, method of operation, and tactical uses of all fire equipment from pumps to minor appliances.

g. BUILDING TYPES AND CONSTRUCTION. To rescue occupants from and extinguish fires in buildings on the post, fire fighters must know building types and construction and building materials used. Tactics to be employed and precautions to be observed will differ in dealing with various types of construction, such as permanent, temporary wartime, and emergency construction. Personal visits should be made to the various types of structures as a part of training procedure until complete familiarity is gained.

h. RESCUES. Rescue training methods should receive basic consideration in the fire department training program. Since it is one of the most important phases of fire fighting, a thorough knowledge of practice and procedures are essential. A weighted dummy can be used in rescue training.

i. First Aid. Although post ambulances usually respond to fires, first-aid practice by fire department personnel should not be neglected. A thorough knowledge and understanding of first aid should be required of all fire department personnel. Red Cross instructors or station hospital personnel can be called upon for first aid instruction.

j. Water Supply. Familiarity with the post water supply is necessary in estimating the number of hose lines that can be laid at all locations. Water relaying, siamesing two or more lines, and use of heavy streams should be studied to meet an emergency involving wide areas or large structures. Training periods held with fire departments of neighboring towns are often desirable.

k. Salvage and Overhaul. Application of accepted salvage operations helps keep fire losses low. Although limited personnel and equipment restrict salvage operations, familiarity with sound practices helps decrease losses. Unnecessary use of water and careless forcible entry must be avoided. Satisfactory overhaul measures are essential to prevent rekindling of fire.

l. Methods. Sound background in fire-fighting methods is needed in selecting correct extinguishing evolutions and equipment. Practice with specific problems in view is essential if maximum results are to be obtained.

m. Protective Clothing and Equipment. Special clothing and equipment are issued to all fire fighting personnel. Clothing and equipment consists of bunking coat, bunking trousers, suspenders, rubber boots, and fire department helmets and an all purpose service mask. Regulation helmet and turn out clothing are worn during response to fire and at subsequent fire operations. For technical details concerning all purpose service mask see TM 3-205.

n. Physical and Mental Fitness. Fitness for duty requires physical and psychological fitness. To apply the knowledge and skills acquired during training and practice, the fire fighter must have stamina and endurance because he may have to perform extraordinary feats of strength in making a rescue. Continuous fitness is maintained only by hard work. Psychological fitness comes with the development of a mental attitude that makes a fire fighter seek additional information and knowledge not specifically required.

4. Competent Pump Operators

The driver of the pumper must not only be a skilled fire fighter but also be able to operate fire-fighting equipment to the best advantage. In addition to the background and training outlined above for the skilled fire fighter, the following requirements must be met by competent operators:

a. Mechanics. Because the operator is responsible for inspection and preventive maintenance of equipment entrusted to him, he must be familiar with manufacturer's instructions, TM 5-687, and Army maintenance manuals for individual trucks. He must be mechanically inclined and treat equipment with respect and care to insure efficient operation and prolong its life. Operating equipment to capacity unnecessarily, slamming gears into mesh, rapid acceleration, sudden stops, and the like are to be avoided. Pride of workmanship is reflected in immaculately clean, proper functioning apparatus. Detailed knowledge of fire apparatus can be acquired during periods allotted for servicing and repairing.

b. Hydraulics. A knowledge of elementary hydraulics is essential for pump operators to secure maximum efficiency from equipment and safety for personnel. Because length of hose lines and nozzle diameters vary, pump pressures must be known to supply safe, adequate pressures at the nozzle. Correct pump pressures for a 50-pound nozzle pressure are listed on a plate at the operator's station of all Army pumping engines. A working knowledge of the post water system is essential to locate apparatus so that adequate water supply is assured. Maps of the post water system, handbooks on hydraulics, and familiarization trips are also necessary.

c. Safe Driving. The safety of the engine crew depends on the judgment and skill of the driver. Equipment must be under positive control of the operator at all times. Post regulations, manuals on driving, War Department regulations, and manufacturers' manuals must be studied in acquiring safe driving practices.

d. Tactics. Operators must learn from experience and study the reasons behind all fire-fighting procedures. Conferences and critiques increase the department's efficiency in getting maximum results from equipment and manpower. Tactics must be understood to prevent confusion and failure during emergency operation.

e. Additional Knowledge of Post. Drivers must know the post layout thoroughly to select the best routes of travel. This knowledge should include off-post terrain if it might prove valuable.

5. Crew Chiefs and Assistant Chiefs

The crew chiefs and assistant chief must not only be proficient in manual and technical phases of firemanship, but possess qualities of leadership.

a. Science of Combustion and Extinguishment. Securing prompt control of a fire emergency requires extensive knowledge of the phenomena of combustion and extinguishment. Textbooks on chemistry and physics are among the sources of detailed information on this subject.

b. Fire Hazards and Inspection. Fire hazards must be elminiated, isolated, or protected. A progressive, vigilant fire-inspection program should prevent fires except those caused by careless disregard of regulations or deliberate intent. Fire prevention is the primary mission of a fire department and cannot be overemphasized. Personnel must be schooled to recognize such fire hazards as improper spacings, unapproved fixtures or installations, hazardous processes, substandard construction, inferior workmanship or materials, and violations of regulations.

c. Knowledge of Post. In addition to knowing the physical layout of the post, senior fire department officers must be familiar with types of organizations stationed there, chain of command, and fixed responsibilities.

d. Tactics. Equipment, personnel, authority for operation, and facilities are usually standard on all Army posts; any difference in effectiveness in the various fire departments depends on *tactics* used by senior officers. Tactics include all methods and procedures used in carrying out the fire department's mission; good tactics result from capable, well-trained senior fire officers.

e. Instructing Ability. Senior fire fighters must be able to instruct others, an ability which some men do not possess although they are masters of their profession. Efficient teaching techniques can be acquired through practice and study; TM 21-250 and TM 1-1000 are recommended sources of information.

f. Self-Confidence. Self-confidence is built on the fire fighter's knowledge that he has mastered all the phases of fire-fighting practices. This self-confident manner inspires subordinates with faith in their superior; it calms excited and frantic personnel at the scene of the fire.

6. Fire Chief

Special traits and skills valuable to the chief of the fire department are discussed below.

a. Leadership Ability. The quality of leadership is directly reflected in operation of the fire department; sound leadership inspires confidence and respect from fire fighters. Mastery of firemanship alone is not enough. The fire chief must be a good disciplinarian to demand unhesitating obedience; he must be tactful, patient, enthusiastic, sympathetic, earnest, level-headed, loyal, truthful, and capable.

b. Administration and Records. The fire chief is responsible for the technical efficiency of fire fighters, mechanical condition of fire apparatus, and enforcement of fire-prevention regulations. He makes and enforces rules, regulations, procedures, and schedules to insure all work being done without omissions. He maintains records to indicate the status of personnel, equipment, and supplies.

c. Fire Prevention and Protection. The fire chief is responsible for carrying out the program for fire-prevention inspections and assumes charge during fire emergencies. Fire prevention and protection methods are based on criteria established in TM 5-600, and TM 5-685. To prevent fires, the fire chief must be able to recognize fire hazards and know how they can be eliminated, isolated, or corrected; he must know how materials are stored, used, or processed without creating unnecessary hazards and how prompt extinguishment is accomplished.

d. Personnel Management. Wise selection of personnel is important because fire fighters being together for extended periods must have personalities that do not clash. Personnel selected must fit into a smooth-functioning unit.

e. Public Relations. Good will built by the fire department is rewarded by the respect and cooperation of other post organizations. Good salesmanship can make personnel fire conscious and fire-prevention measures can be easily established; this selling is usually done by inspectors on their rounds, posters, signs, demonstrations, and lectures. The fire department must convey the idea that it is helping units on the post prevent fires.

f. Knowing the Post. For harmonious operation and efficiency, the fire chief must know channels of supply, authority, and communication on the post.

g. Tact and Diplomacy. Because personality of the fire chief has an important bearing on the success of the fire department as a whole, tact and diplomacy are almost as valuable as skill and knowledge.

SECTION III

FIRE EXTINGUISHERS

7. General

Fire extinguishers are first-aid appliances designed to extinguish small fires before they reach major proportions. Placing extinguishers of the proper type and in the proper location for the hazard involved increases the likelihood of extinguishing fires with a minimum property loss. Distribution and spacing of fire extinguishers at Army installations must be in accordance with War Department criteria and TM 5-685. Successful operation of fire extinguishers depends largely on the skill of the user; familiarity with the location and operation of extinguishers is essential to all personnel who may have to use them Presence of mind must be stressed in instructing personnel to use first-aid extinguishers. Hand fire extinguishers have the same function as larger capacity equipment; to confine and extinguish the fire.

8. Classification of Fires

Accepted practice classifies fires according to the fuel involved.

a. CLASS A. Fires in ordinary combustible materials where the cooling or quenching effect of water or solutions containing water is the extinguishing factor are class A.

Examples: frame construction, overstuffed furniture, waste basket, and the like.

b. CLASS B. Fires in inflammable liquids, greases, and so on, where air exclusion or blanketing is essential, are class B.

Examples: deep fat fryers, gasoline tank trucks, vats of cleaning solvent.

c. CLASS C. Fires in electrical equipment, where a nonconducting extinguishing agent is of first importance, as class C.

Examples: electric motors, switchboards, transformer banks.

9. Classification of Extinguishers

War Department purchases only fire extinguishers bearing the Underwriters Laboratories label, indicating that certain requirements for extinguishing value, safety, and reliability have been met. The following tests are performed by the Underwriters Laboratories to determine the extinguishing value. The capacity of an extinguisher is taxed to the utmost and the nature of the tests illustrates the need for skill by the user to get maximum benefit from an extinguisher.

a. CLASS A. For class A extinguishers, the test set-up consists of a 10-foot-square, tongue-and-groove backboard with two layers of 1-inch by 1-inch strips set 1 inch apart and nailed over 1- by 1-inch battens spaced 1 foot apart. Kind of wood and its condition must be controlled so comparative results can be obtained. This panel is permitted to burn until the entire panel is fully involved and the fire is deep seated. Extinguishing every ember constitutes a unit of fire protection; an extinguisher meeting this test is rated A1; if two are required to put out the fire, an A2 rating is given. The letter denotes the class of fire; the number indicates the number of extinguishers needed for one unit of protection.

b. CLASS B. The test set-up for determining the unit of fire protection for class B fires consists of a tub 4 feet in diameter with enough gasoline to cover the tub bottom. The extinguisher tested must put out all fire when operated from one side of the tub. Foam extinguishers must produce a foam blanket 1½ inches thick with no openings to permit vapor to escape.

Note. Extinguishers may be rated as both A and B if they meet the requirements for both classes.

c. CLASS C. Tests for class C fire extinguishers are more complicated than tests for class A and B fires. The test determines the conductivity of the extinguishing agent. Thus, with a vaporizing liquid, 12,000 or 30,000 volts are impressed on electrodes, the electrodes dipped into samples of the liquid at a known distance apart, and the conductivity of the liquid measured. Similar tests are made on gaseous extinguishing agents. A further requirement is that carbon dioxide or gas-expellent extinguishers be equipped with nonconductor horn.

10. Types of Extinguishers

Fire extinguishers operate on two basic principles: by cooling or quenching burning material below ignition temperature (water type), and by excluding oxygen with a blanket of foam or gas (foam, carbon tetrachloride, and carbon dioxide extinguishers). The following types are used by the Army:

a. WATER-PUMP TANKS. Water-pump tanks, issued in 2½-, 4-, and 5-gallon sizes, have a fixed

pump which can throw a stream of water 30 to 40 feet. (See fig. 2.) Since their extinguishing agent is water, they are best suited for class A fires. For best results with water-pump tanks—

(1) Use a series of short, rapid strokes of the pump to produce a continuous stream.

(2) Keep the nozzle as close as possible to the fire.

(3) Direct the stream of water at the seat of the fire instead of at the smoke and flame.

(4) Refill pump-tank extinguishers by bucket brigades to insure continuous operation.

(5) Do not direct the stream in a series of short jerks by trying to cover the entire area simultaneously.

(6) If the extinguisher nozzle does not have a spray attachment and spray is needed to fight the fire, form it by placing a finger at the tip of the nozzle.

(7) Protect the extinguisher from freezing in cold weather. (See TM 5-687.)

b. Soda-acid Extinguishers. Soda-acid extinguishers are fundamentally water type extinguishers using 2½ gallons of water fixed with 1½ pounds of bicarbonate of soda. (See fig. 3.) When the extinguisher is inverted, a suspended bottle containing 4 ounces of sulfuric acid empties into the soda solution; this produces carbon dioxide gas under pressure which expels water for a distance of 30 to 40 feet. The carbon dioxide has little or no extinguishing value. TM 5-687 describes the method of recharging and reassembling this type of extinguisher.

Once the extinguisher is inverted for use, the fluid flows continuously until expended unless it is again placed upright. For proper operation of soda-acid types—

(1) Carry soda-acid extinguisher to the fire in upright position and invert only when ready for use.

(2) Direct stream from close range rather than from extreme limits.

(3) Direct stream so water cools and quenches burning material at the seat of fire.

(4) If spray is desired, form it by placing finger over end of nozzle.

(5) Protect against freezing in colder climates by placing extinguisher in heated building. Do not add chemicals to lower the freezing point as such chemicals destroy the pressure-building reaction between soda and acid. Sometimes soda-acid extinguishers are housed in a closed box with a small lamp or heating device installed to keep extin-

Figure 2. Pump-tank types.

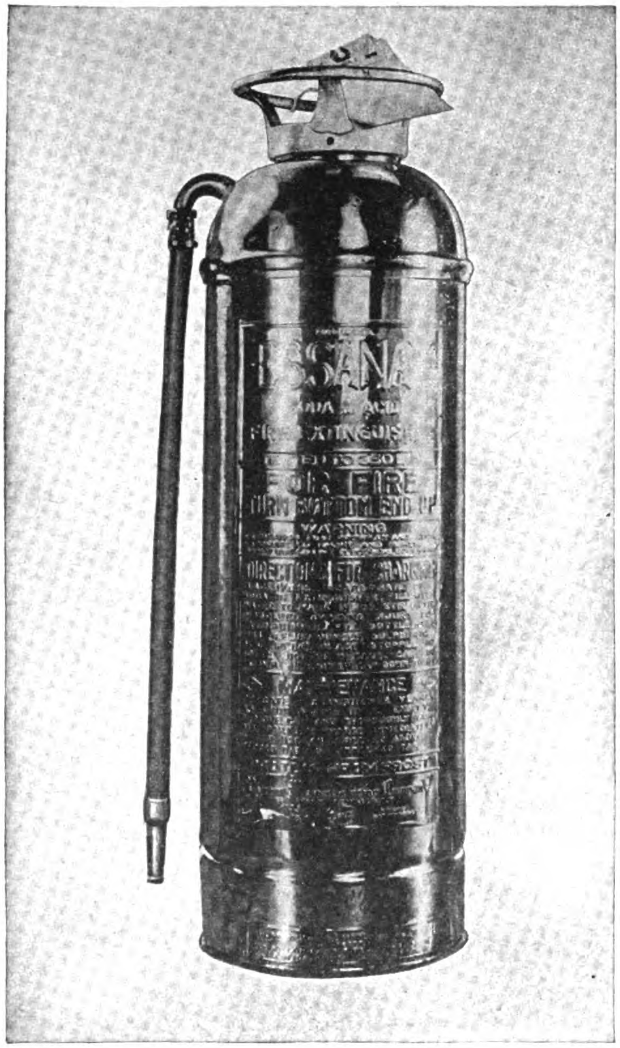


Figure 3. Soda-acid type, 2½-gallon capacity.

guisher from freezing. See that this device does not create a fire hazard.

(6) Operate the 40-gallon type the same as the 2½-gallon extinguisher. This extinguisher has a shut-off nozzle to permit greater latitude in using the extinguishing fluid.

c. FOAM EXTINGUISHERS. Foam extinguishers are similar in appearance to the soda-acid type. (See figs. 4 and 5.) However, because the foam discharge is a frothy mass, a larger nozzle is needed. The extinguisher has an outer chamber holding a mixture of sodium bicarbonate and 7 quarts of water and an inner chamber holding a solution of aluminum sulfate in 2¼ pints of water. To these chemicals is added a foam stabilizer.

The extinguisher is also put in operation by inverting it, mixing the two solutions to produce carbon dioxide gas which is the expelling force. The resultant foam is a durable mass of carbon dioxide bubbles; a 2½ gallon foam extinguisher produces about 15 to 18 gallons of foam. Procedure for charging foam extinguishers is given in TM 5-687. Foam recharges should be procured from reliable sources, preferably the manufacturer of the extinguisher. Some substandard recharges are subject to mold with consequent decrease in efficiency. For proper operation, follow the procedures below.

(1) Use foam type extinguishers for class B fires involving inflammable liquids. The foam floats on the surface, forming a blanket between the fuel and the air. Fluids such as alcohol and acetone require a special foam because they act as a solvent and destroy standard foam bubbles. Foam is also effective for class A fires. However, it does not penetrate finely divided materials as well as water does.

(2) Protect extinguishers against freezing by installing them in heated buildings or heated cabinets; do not add chemicals. Cold weather affects the

Figure 4. Foam type, 2½-gallon capacity.

Figure 5. Pump-tank type, 4-gallon capacity, converted to foam type.

foam-producing characteristic of this extinguisher adversely.

(3) Apply foam to a flaming liquid surface as gently as possible.

(4) Allow the stream to strike against the walls of the container and flow down to the surface of the liquid.

(5) Where possible, assist the foam blanket to spread by moving around the hazard.

(6) Avoid directing the stream into the surface as it will become saturated with the liquid involved. The heat of the fire causes the foam to break down, retarding extinguishment.

(7) Where nozzle pressure is too great, reduce the force by placing a finger at the nozzle tip.

(8) Apply foam from extreme range of the stream so it reaches the surface with most of the propelling force gone.

(9) Where the burning fluid is spilled on a flat surface, direct the stream against the ground near the fire so it rolls or flows over the area involved.

d. Carbon Tetrachloride Extinguishers. Carbon tetrachloride extinguishers use a special extinguishing compound having a carbon tetrachloride base with certain ingredients added to lower the freezing point and resist corrosion. The Army uses pump-operated or stored-pressure types (fig. 6); the 1-quart size is of two types: one pumping out the liquid directly, the other pumping in air to expel the liquid. Carbon tetrachloride is very volatile, evaporating to form an inert gas heavier than air. This gas extinguishes fire by air exclusion or dilution. The liquid is only about 10 percent as effective as water for cooling or quenching. Since carbon tetrachloride is a nonconductor of electricity, this extinguisher is used for electrical fires.

Since carbon tetrachloride absorbs water vapor, creating a corrosive mixture that attacks the extinguisher parts and frequently results in failure, fire-extinguisher fluid must be kept in sealed containers as a protection against atmospheric moisture. Commercial carbon tetrachloride for cleaning or solvents should not be used in extinguishers. For best results—

(1) Avoid breathing gases produced by this extinguisher in a confined space. Carbon tetrachloride vapor has an anaesthetic effect and if subjected to high temperatures decomposes to some extent, forming toxic gases, including hydrochloric acid and phosgene. These gases are highly poisonous, but the vapors are sufficiently irritating so that there is no danger of anyone being overcome with these gases without being aware of their presence.

(2) Assist vaporizing to form a spray by placing finger over the discharge hole.

(3) Direct liquid toward seat of fire.

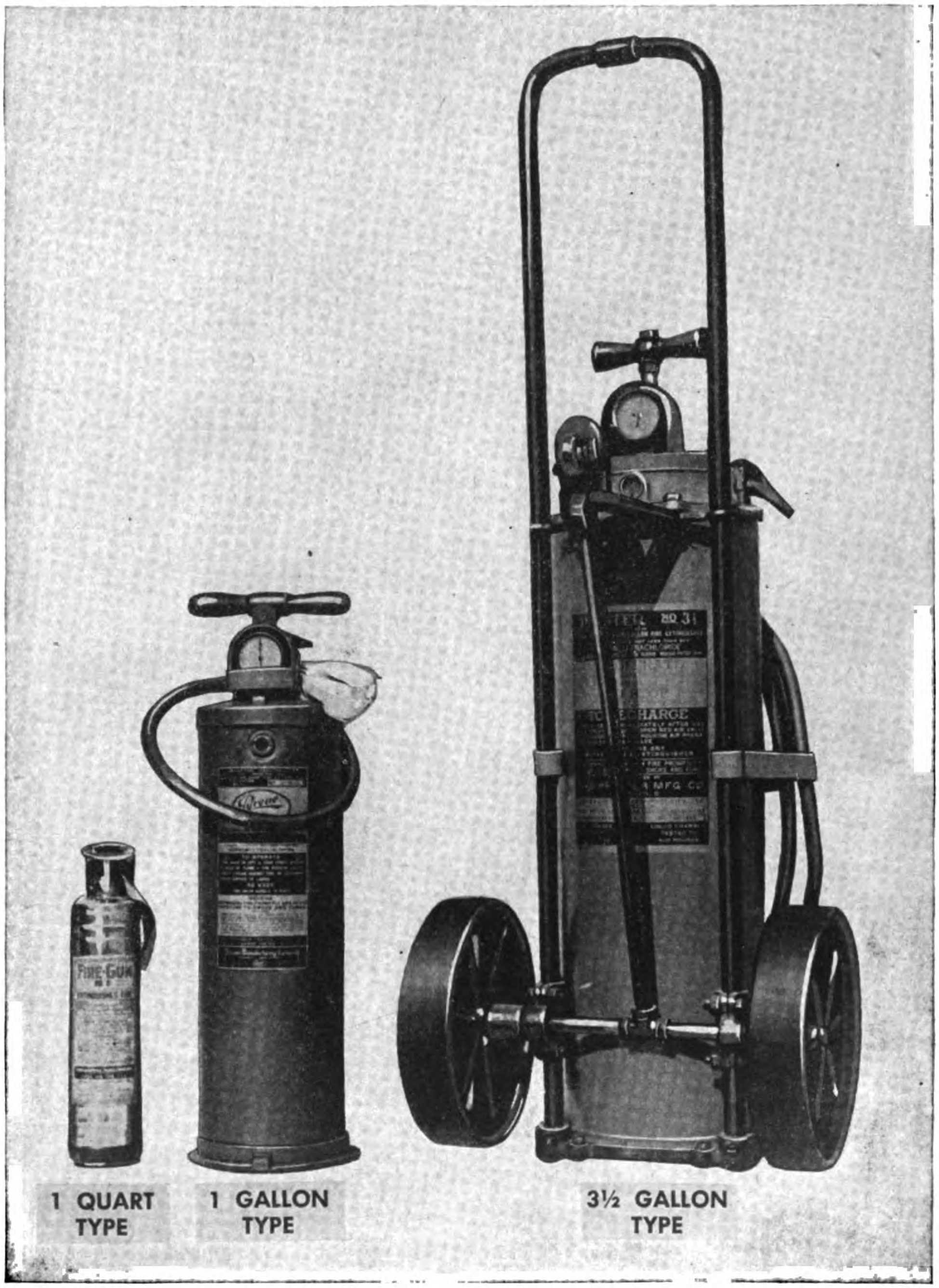


Figure 6. Carbon tetrachloride extinguisher.

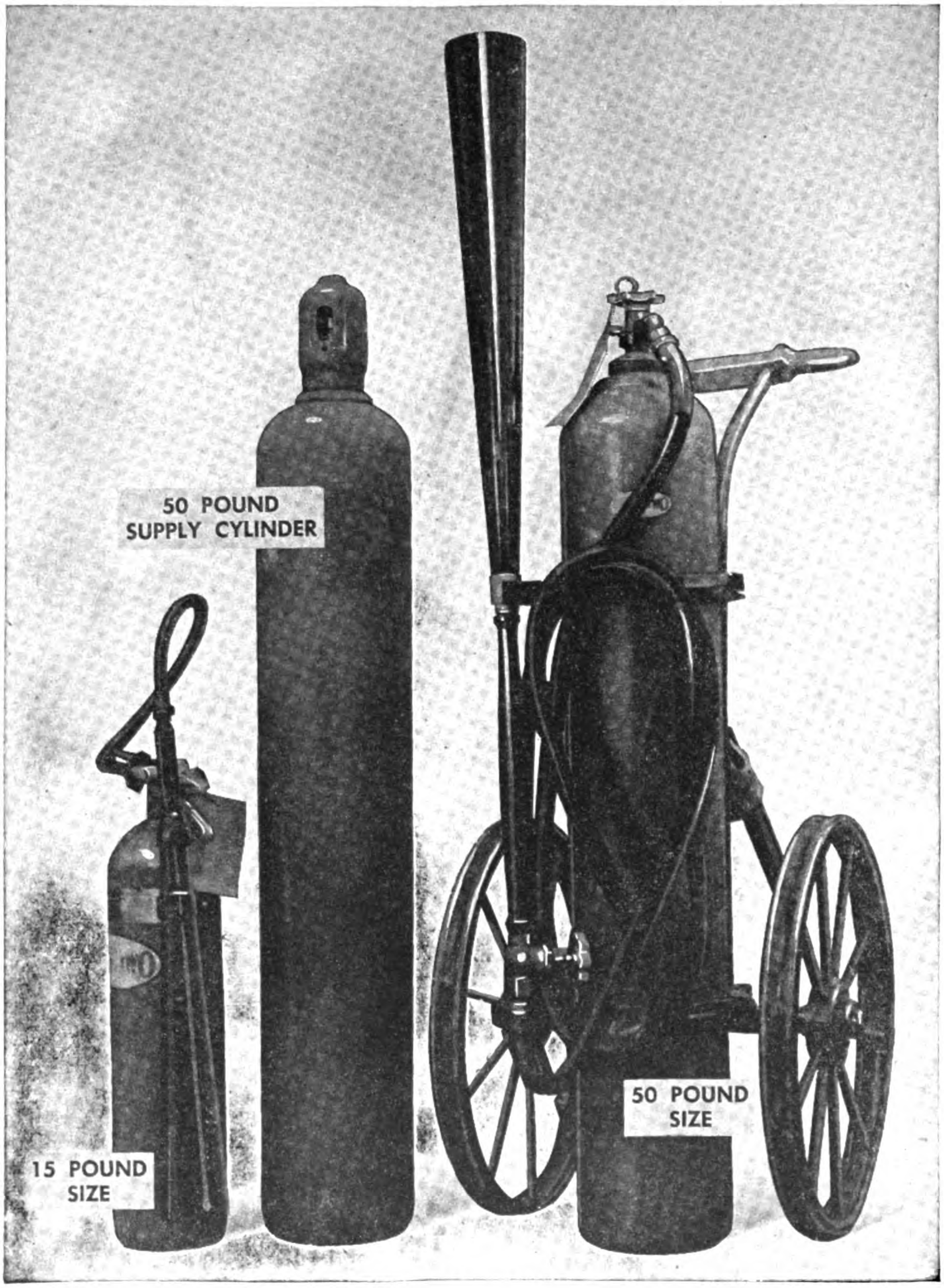


Figure 7. Carbon dioxide extinguishers and supply cylinder.

(4) When used on tanks or vats, direct extinguishing fluid against the container wall or other freeboard. Do not direct stream into burning liquid. If practical, walk around the fire to provide greater coverage.

(5) Take advantage of any wind or draft so smoke and fumes are blown away from the user.

e. CARBON DIOXIDE EXTINGUISHERS (fig. 7). Carbon dioxide is an inert gas that extinguishes by displacing air or diluting its oxygen content. When carbon dioxide is stored in a cylinder or tank below its critical temperature of 88° F., it changes from a vapor to a liquid. On release to the atmosphere, the highly volatile carbon dioxide gas comes out as a vapor and snow. The liquid carbon dioxide in converting into a gas expands in a ratio approximately 500 to 1. Because of this sudden expansion, the temperature of the snow or solidified portion of the discharge is –110° F. The heat-absorbing capacity of carbon dioxide is very

limited, being only about 10 percent as efficient as water. Internal pressure generated by carbon dioxide stored in a tank or cylinder is proportional to temperature. For this reason, carbon dioxide extinguishers should be protected from the direct rays of the sun because pressure may rupture the frangible safety disk. This high internal pressure at normal temperatures requires containers of heavy materials. An empty 15-pound extinguisher weighs about 35 pounds.

For proper operation of carbon dioxide gas extinguishers—

(1) Direct the discharge at the base of the fire because carbon dioxide gas extinguishes fire by air exclusion.

(2) Extinguish ground fires first, working progressively upward to prevent reignition.

(3) When extinguishing a large area, establish and maintain a wall of inert vapor between blazing and extinguished portions of the fire. This wall must remain unbroken and moved across the involved area to snuff out the fire at the far end.

(4) Since the reach of a carbon dioxide stream is limited, work with any breeze or draft at the back.

(5) Consider the definitely limited capacity of carbon dioxide extinguishers. If a fire is beyond the capacity of one extinguisher, the carbon dioxide discharged produces no lasting results.

(6) If the fire is beyond the capacity of one extinguisher, use two or more extinguishers simultaneously to produce larger coverage. Use of several extinguishers one after another will not ordinarily be effective.

(7) Move the discharge horn of a carbon dioxide extinguisher at a moderate rate to form a bank of gas. Rapid movement dissipates the vapor as it is discharged; too slow movement may discharge more than is needed at one point. Acquire proper technique under varying conditions by experience.

(8) Confine the discharge to the burning material or area to prevent possible flashbacks. This procedure also takes advantage of the cooling capacity of carbon dioxide snow.

(9) Because carbon dioxide extinguishes fire by air displacement most effective extinguishment can be done in confined spaces where the gas can blanket the fire.

Caution: Carbon dioxide extinguishes fire by depleting the oxygen supply to below 15 percent which is also the critical concentration for sustaining human life. The chief hazard to personnel from carbon dioxide is suffocation; the freezing effect of the snow is not serious unless exposed portions of the skin are directly sprayed.

f. SPECIAL EXTINGUISHERS. Several types of fire extinguishers are in use by the Army occasionally. A brief description of their principal features of dissimilarity follows:

(1) Loaded-stream water type extinguishers containing an alkali-metal-salt solution added to lower the freezing point. The expelling force is usually provided by puncturing a stored-pressure cartridge. An adequate supply of cartridges and recharges for normal operation must be kept on hand.

(2) Plain water type extinguishers using a cartridge to provide discharge pressure. Operating action is initiated by puncturing the cartridge. Maintenance includes periodic inspection of the cartridge for gas leakage.

(3) Dry-compound extinguishers using a specially treated bicarbonate of soda in dry powder form with a cartridge of carbon dioxide as an expellent.

SECTION IV

FORCIBLE ENTRY

11. General

Forcible entry means gaining access to closed spaces by opening locked doors and windows, roofs, floors, skylights, partitions, and walls by mechanical means. Even breaching masonry walls with a battering-ram and other extreme operations may sometimes be necessary. Forcible entry is often destructive. However, promiscous destruction of buildings must be discouraged; responsibility for careful, forcible entry rests directly with the fire department. Forcible entry methods discussed in this section have been proven through practice.

a. Tools. Special tools peculiar to the fire service have been designed for use in forcible entry. (See fig. 8.) Many are developments of expedients devised in emergencies; several items not regularly supplied have been made on individual posts. One of the most useful of the forcible-entry tools is the pick-headed ax. Roofs and floors cannot be breached properly without a thorough understanding of its uses. To an experienced fire fighter its adaptability to special uses makes it particularly valuable. Its great advantage over a chopping ax is the pick, which is used for prying and digging. It can be used to pull up flooring and roof boards, remove partitions, and pull lath and plaster inaccessible to other tools.

(1) *Blade.* The blade must be tempered so it does not bend easily or break off when nails, gravel, or other hard materials are struck. If it is extremely sharp and the body is ground too thin, it breaks when cutting gravel roofs or striking nails and other hard materials. If the body is too thick, the ax cannot be driven through ordinary flooring regardless of blade sharpness. Recommended body thickness is ¼ inch at ¾ inch from the edge, ⅜ inch at 1¼ inches, and ½ inch at 2 inches, all measurements being taken at the center of the blade.

(2) *Grinding.* Care is necessary in grinding an ax to prevent overheating and annealing the steel. The ax must be ground to preserve body thickness, not merely to sharpen the blade. After sharpening the blade, it is rubbed lightly over a stone to take off the keen edge and lessen danger of cutting fire fighters.

(3) *Handle.* The handle's shoulder is left rather thick to prevent breaking if the ax is driven through a floor unexpectedly. The grip is polished and is thin to provide elasticity. The handle must not be painted or varnished, but linseed oil may be applied to prevent roughness and warping. If axes are painted, the paint must be carefully removed and handles treated with linseed oil.

b. Cutting with an Ax. When cutting with a fire ax, short, quick strokes are used to avoid hitting other men or catching the ax in overhead obstructions. This is particularly important in dark or smoke-filled places. Short strokes save time by

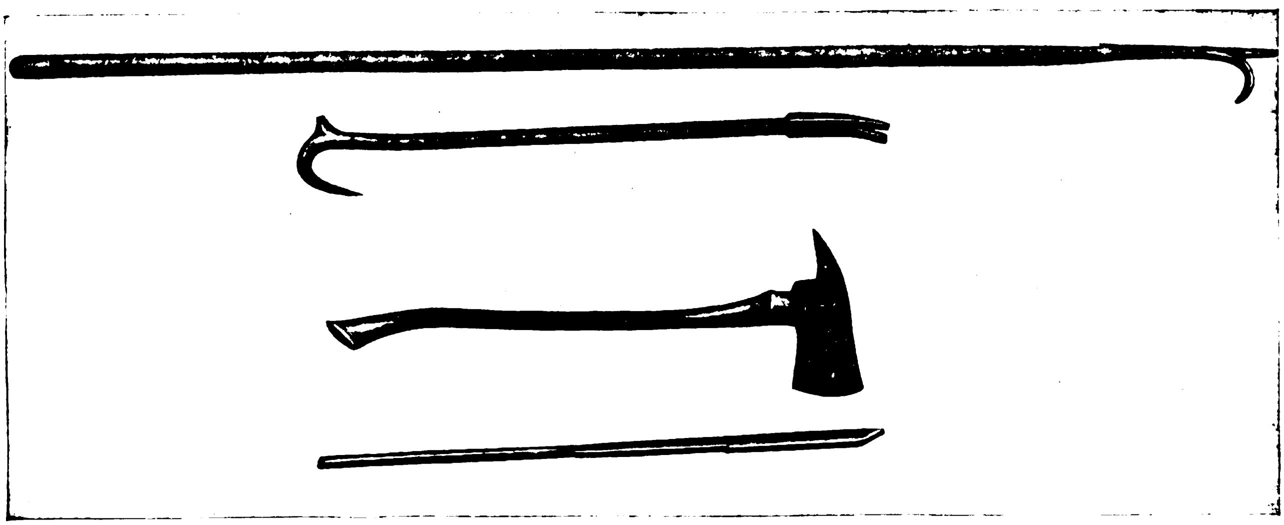


Figure 8. Forcible-entry tools furnished on Corps of Engineer fire trucks. Shown are pike pole, door opener, pick-headed ax, and crowbar.

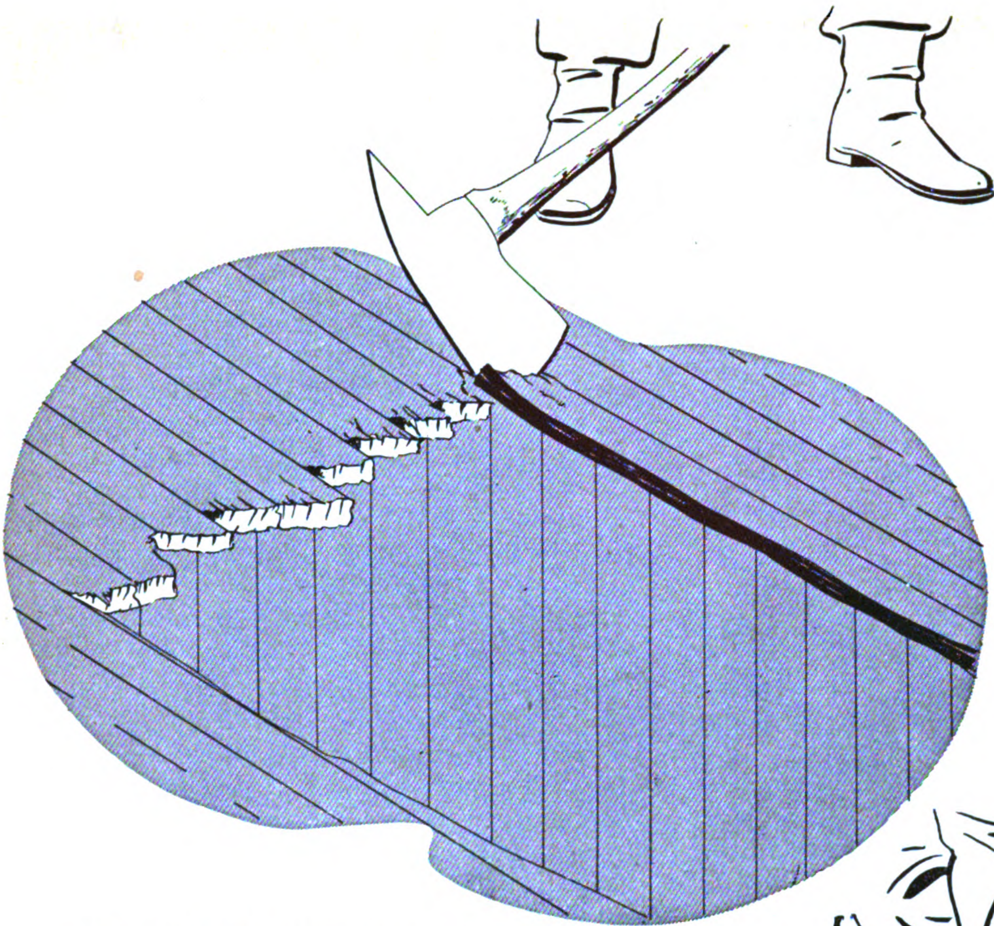


Figure 9. Using the firemen's ax on flooring.
① *Cut flooring at an angle so it can be pried out easily. Correct position of the feet reduces danger of being struck by glancing blow.*

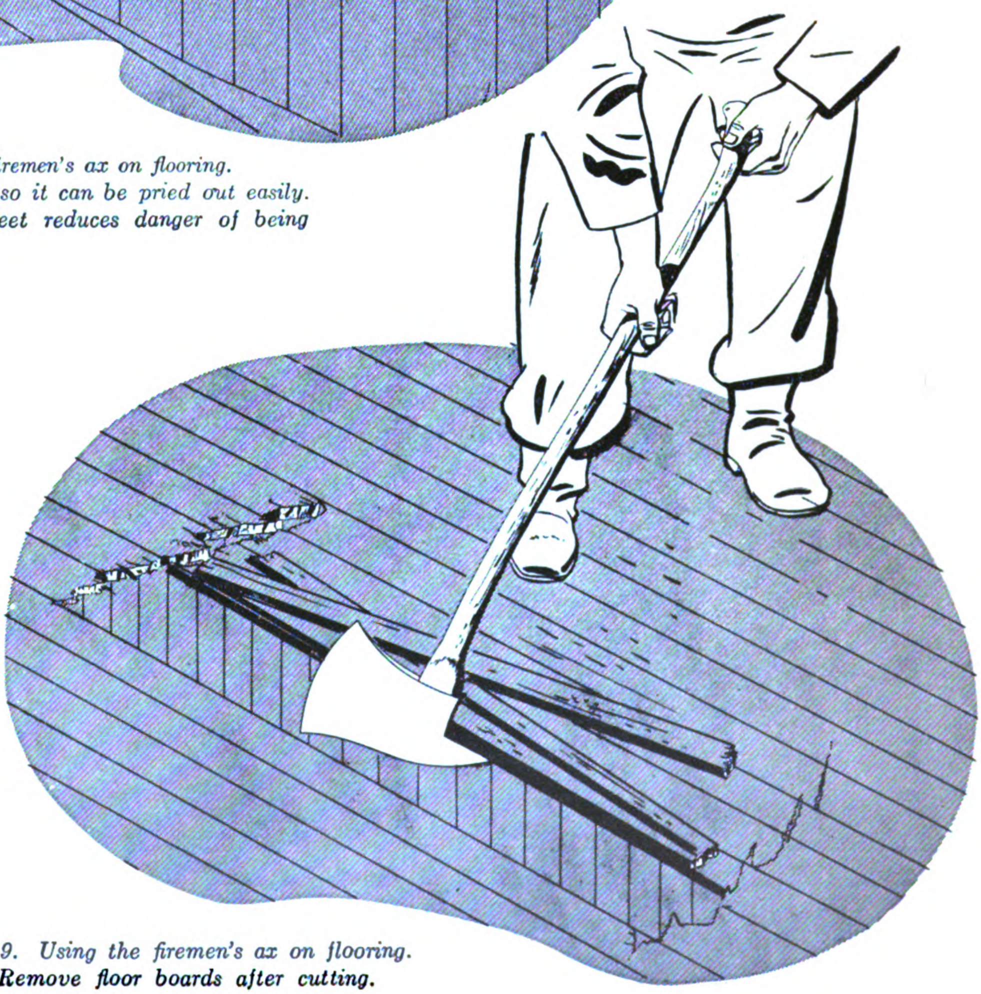


Figure 9. Using the firemen's ax on flooring.
② *Remove floor boards after cutting.*

insuring better control of the point of entry of the ax blade. Cuts are made diagonally, not with the grain of the board, and as close to a joist or stud as possible. A fire fighter should be able to cut either right- or left-handed. Cutting in difficult corners and under obstructions can be done only by men who have been properly trained.

(1) *Flooring, roofing, and sheathing.* Cuts in flooring, roofing, or sheathing are made at an angle of about 60° across instead of straight down. (See fig. 9.)

(2) *Diagonal sheathing.* Diagonal sheathing is cut in the direction the sheathing runs so chips will tend to split out. If cuts are made against the sheathing, the ax may bind and require extra effort.

(3) *Lath and plaster.* Cuts through a lath and plaster wall are made in a direction diagonal to the grain instead of straight across it.

12. Procedure

a. OPENING DOORS. (1) *Types of doors.* Types of doors found at Army installations are illustrated in figure 10 and described below.

(*a*) Ledge doors, sometimes called batten doors, are made of built-up material; they must be locked with surface locks, either hasps and padlocks, bolts, or bars. Hinges on ledge doors generally are of the surface type, fastened with screws or bolts.

(*b*) Panel doors may be either cross or vertically paneled. The panels are of thin material and dadoes, not glued, into the stiles and rails. Either surface or mortised locks may be used, and hinges may have full surfaces, half surfaces, or hidden butts. Hinges generally have loose pins that are easily removed. (See fig. 11.)

(*c*) Slab doors are generally made of veneered hardwood with white-pine core. They take the same general hardware as panel doors and are very solid and not easily sprung.

(*d*) Industrial doors, used in garages, warehouses, and storehouses, are double or single sliding, overhead lift, or overhead rolling.

(2) *Methods of opening.* The method for opening doors is determined first by the way the door is hung in the frame, and then by the way it is locked. Outside doors in barracks, store buildings, recreation halls, and smaller doors of other buildings are set either against stops in the frame or against a rabbeted shoulder in the door jamb. Doors on Army installations generally open outward. Figure 12 shows one method of opening doors.

(*a*) Overhead rolling doors are made of steel and offer the greatest resistance to forcible entry. Normally, these doors cannot be raised except by operating a gear and chain. Prying on such a door may spring it so the gear will not work. A cast-iron plate can be installed in the wall near the chain and this plate can be broken to permit reaching the chain and raising the door in an emergency.

(*b*) If doors are only stopped in the frame, the stop can be raised with a sharp wedge and the door swung clear of its fastening. (See fig. 13.)

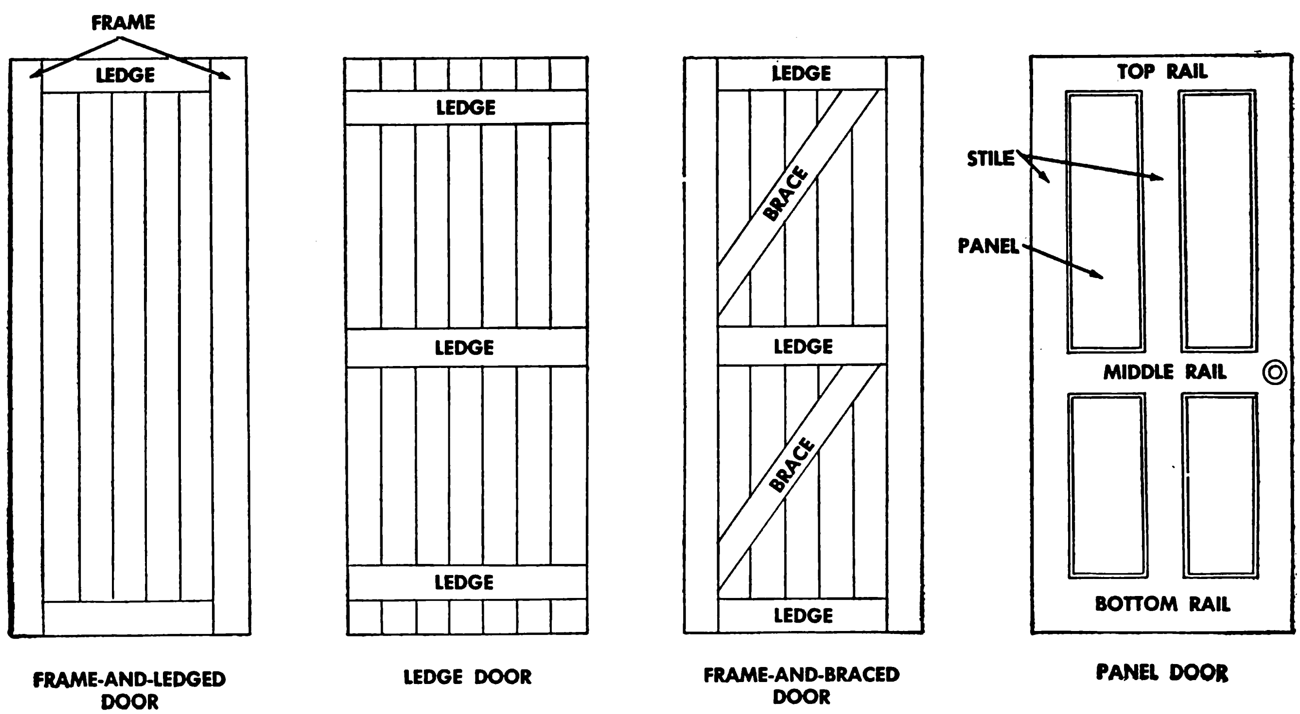


Figure 10. Common types of doors at Army posts.

Figure 11. Hinge pins can be removed by tapping with ax or spanner wrench. This method saves damaging door or casing.

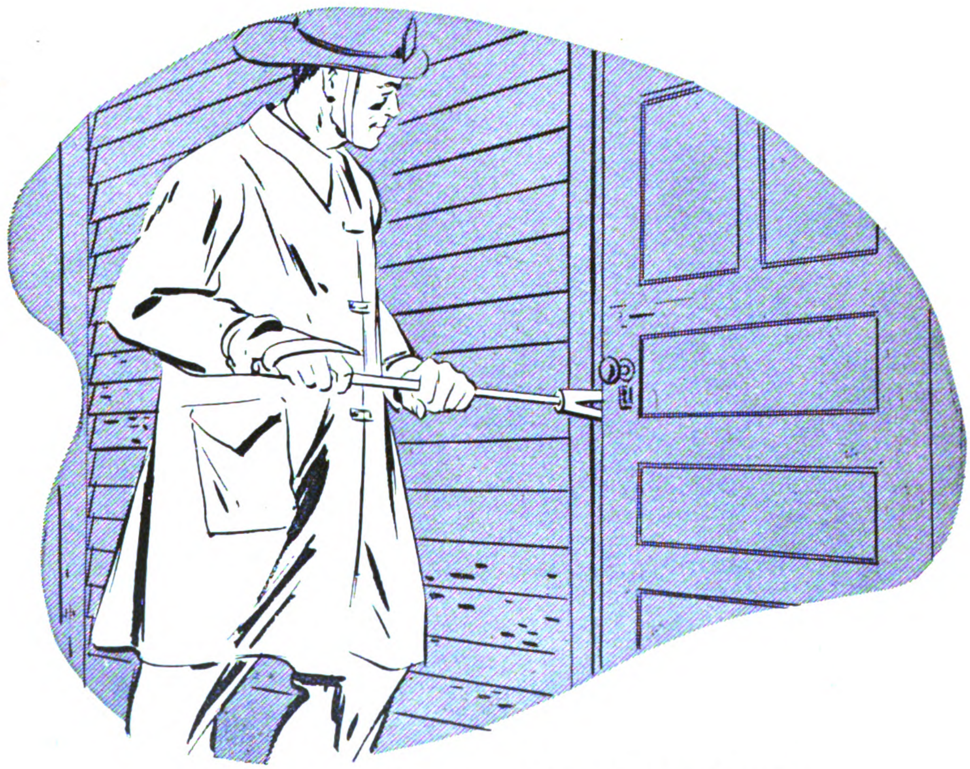


Figure 12. Using door opener. Wedge should be inserted just above or below lock. Spanner wrench may also be used.

(*c*) If the door is set in a rabbeted frame, entry is not easily made. Figure 14 shows how such a door can be opened by splitting the jamb or breaking the lock bolt. Figure 15 shows how the same door can be opened with the wedge of an ax or door opener; both door and jamb will be damaged slightly, but the door can be closed again.

(*d*) A door opening outward can be opened by inserting a door opener or the blade of an ax in the crack between door and jamb, prying them apart until the bolt clears. (See fig. 15.)

(*e*) Double doors can be opened by prying between the doors until the bolt of the active door

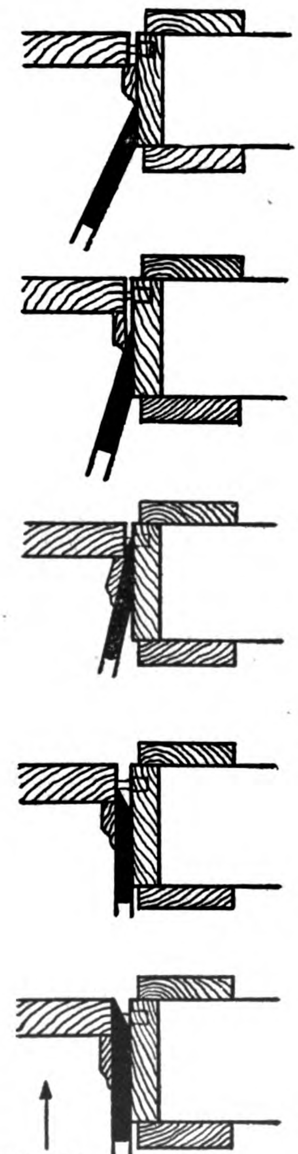


Figure 13. Springing a door in a stopped frame with a door opener. Tool should be used to separate lock and jamb enough for lock to pass keeper.

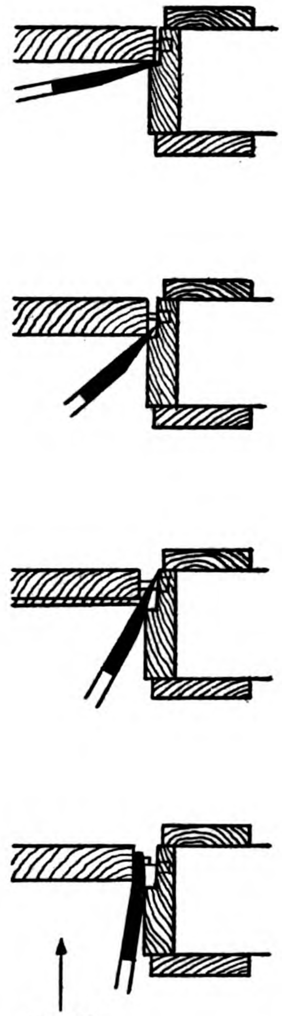


Figure 14. Opening door in a rabbeted frame.

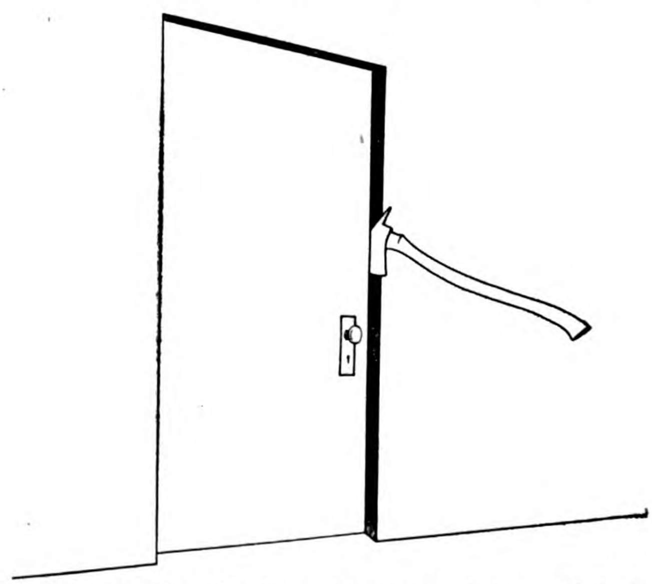


Figure 15. Opening door with pick-headed ax. Blade is inserted above or below lock and pried to allow bolt to pass keeper.

clears. If an astragal covers the opening, it must be cut away before inserting the wedge.

(*f*) Night latches should yield to the same prying as mortised locks, but if they are fastened on the surface of the door with screws, they can be bumped off by ramming the door with a heavy object or a man's shoulder.

(*g*) Overhead-lift doors can be forced by prying upward at the bottom of the door with a crowbar or claw tool. Once the lock bar is broken, the doors open readily.

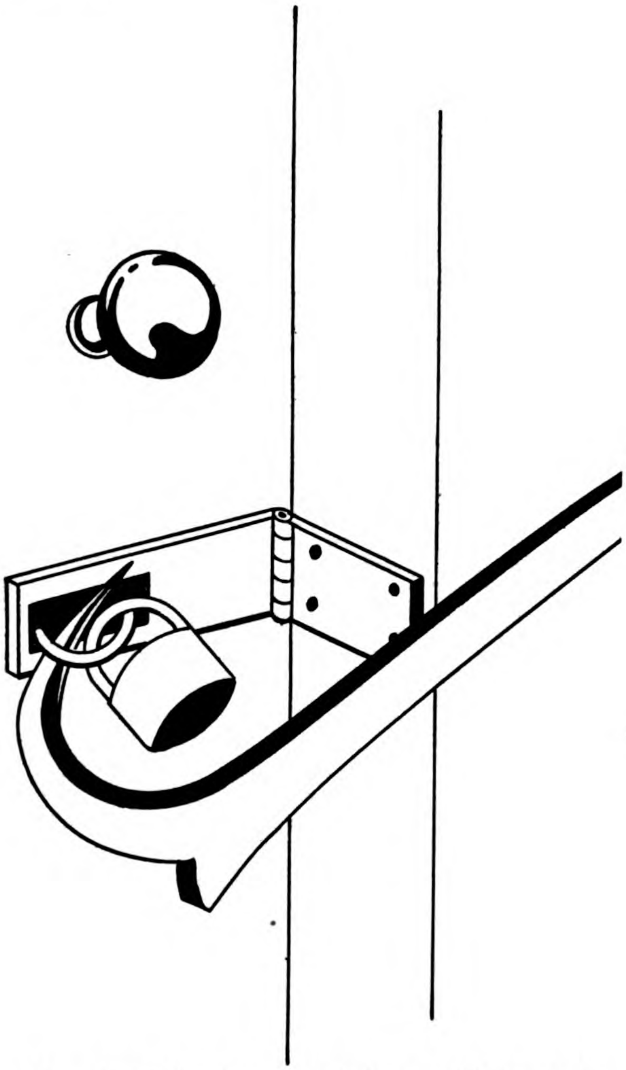


Figure 16. Using door opener in hasp avoids damage to padlock.

(*h*) If single-hinged doors such as those on warehouses and stables are locked with a hasp and padlock, the staple of the hasp can be pried or twisted off with a door opener. (See fig. 16.)

(*i*) Many double warehouse doors are secured with a bar dropped into stirrups on the inside of the wall. The door must be battered in or the wall breached with a battering-ram. The breach is made at a point which permits slipping the bar from the stirrups. For ordinary brick walls, battering a hole large enough for a man to enter and unlock the doors from the inside is sometimes the quickest and least destructive method of access.

b. Opening Windows. Prying with a wedge is the principal operation in forcing windows. The fire-fighter's ax, the claw tool, or other wedge-shaped instrument can be used. If the wedge is wide and thin, entry can be forced with little damage. Types of windows and methods of opening them are discussed below.

(1) Factory-type windows have steel sashes which are often set solidly in the frame so only a part of it can be opened. The movable part is generally pivoted at the center or hinged at the top, and latched on the inside. Since factory windows have small panes, breaking a glass near the latch is easier. Jagged pieces of glass left on the sash are cleaned out before the hand is inserted. Wired glass must be removed from the sash.

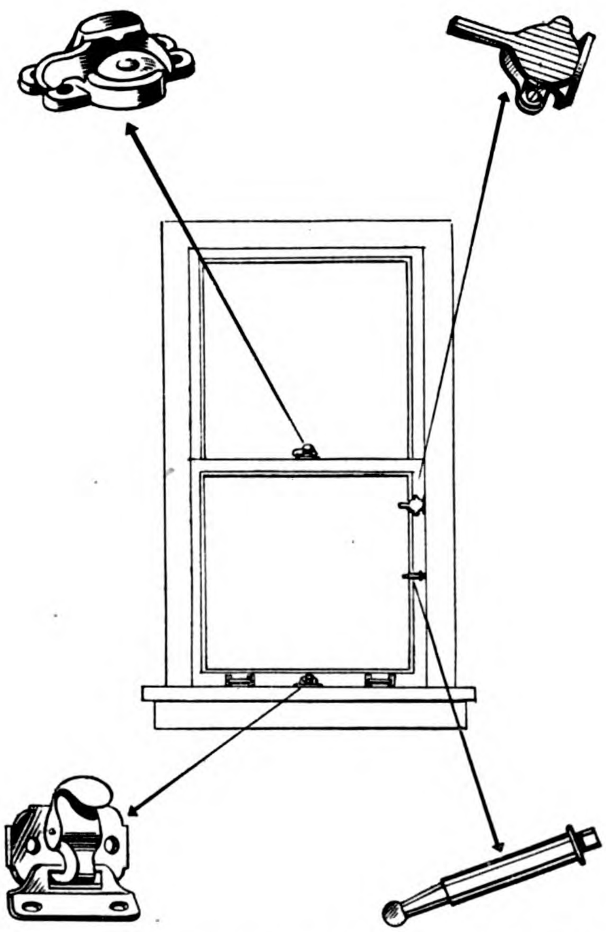


Figure 17. Locking devices that may be encountered in check-rail windows.

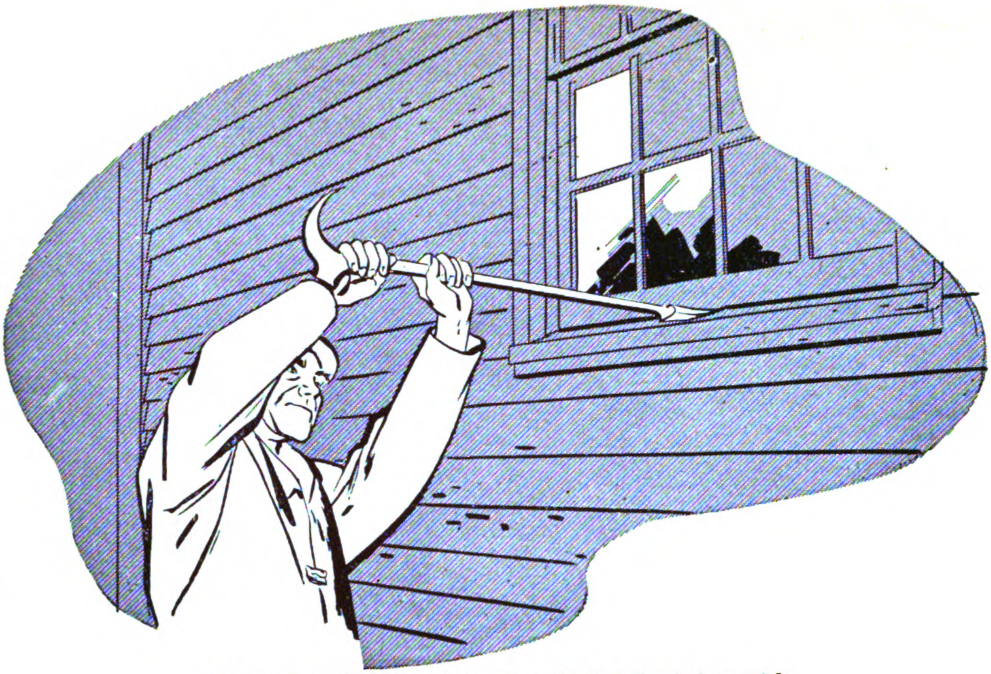


Figure 18. Method of opening check-rail window with window opener. Ax or spanner wrench may also be used.

(2) The check-rail window having two sashes that meet horizontally is the type commonly used. If the sashes are hung with weights, they are locked together. If the window has no weights, the sash is locked with bolts in the window stiles or by a friction lock pressing against the window jamb. (See fig. 17.) Check-rail windows can be opened by prying upward on the lower sash rail. (See fig. 18.) If the window is locked on the check rail, the screws of the lock give and the sashes separate. If it is locked with bolts, they must be broken or bent before the sash can be raised. Prying should be done at the center of the sash to prevent breaking the glass. However, if the check-rail latch is on the side, the pry should be made directly beneath it.

(3) Basement windows can be opened in the same way as a door in a rabbeted frame. If the prying is done at the center of the lower rail, the lock may be pulled off or sprung.

(*b*) To open windows on upper floors to provide ventilation, the fire fighter lies face down on the roof or leans from a window on the floor above, applying the point or hook of pike pole to window below. (See fig. 19.) The pike pole can also be used to break the glass if the window cannot be raised or lowered.

(5) Casement sashes are hinged to the window jambs and meet vertically; they either are locked together or to the window frame. Casement windows can be opened much the same as double doors.

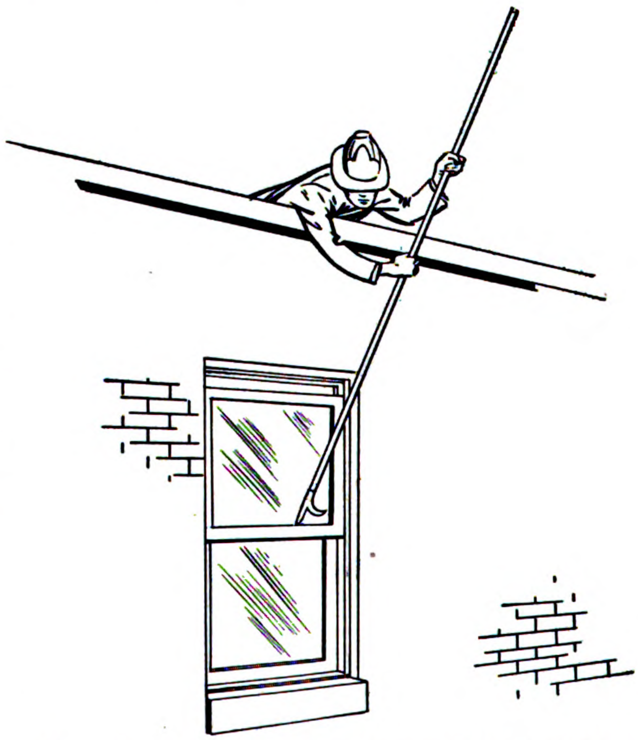


Figure 19. Using pike pole to open window from above.

Generally they are securely locked and breaking the glass is necessary. Casement sashes of wood are generally hinged at the top and locked at the bottom; metal sashes may be hinged either at the bottom or at the top.

c. Opening Roofs. Roofs can be classified ac-

cording to the construction of the covering as shingle roofs, composition roofs, or metal roofs.

(1) Shingle roofs include all those made of small section of material fastened to the sheathing, such as wood, metal, or asbestos. Shingles are nailed to sheathing and can be removed easily. Shingle roofs are opened by stripping off the shingles and cutting away the sheathing.

(2) Composition roofs have one to six sheets of roofing material, generally tarred felt, nailed to the sheathing and cemented together with asphalt. Hot asphalt that hardens when it cools is spread over the entire covering. Gravel may be spread into and over the hot asphalt to become a part of the covering when it cools. The sheathing consists of 1-inch shiplap laid tight on wood joists or on solid concrete. Composition roofs require more care in opening because they are more difficult to repair. The covering is cut and rolled back before the sheathing is cut away to make an opening. The roof should be sounded before cutting to locate joists and cuts should be close to the joist to make both cutting and repair easier.

(3) Metal roofs, generally tin plate, have sheets

Figure 20. Removing lath and plaster ceiling. Position of hands on top of pole insures downward and outward pull so ceiling will not be pulled on top of fire fighter.

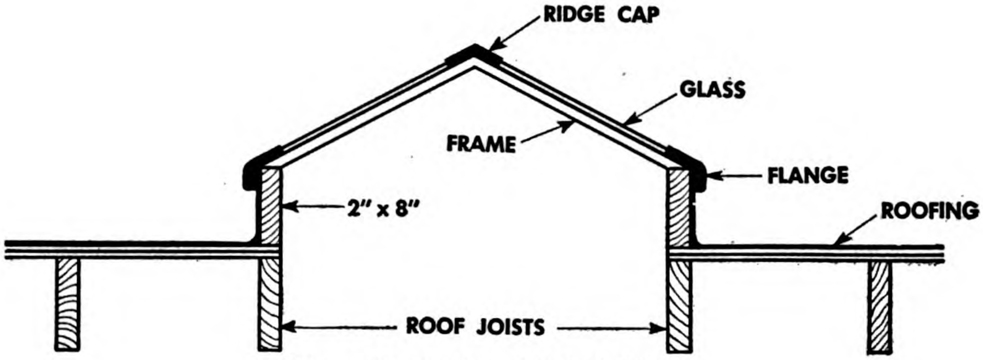


Figure 21. Section of typical skylight.

of metal crimped or soldered together as one sheet. The sheets are fastened to sheathing the same as for wood construction under composition roofs.

Caution: Always work with the wind at the back so gases and fire coming through the opening do not hinder worker. After a roof is opened, open the ceiling below by forcing it down with a pike pole or other tool. A ceiling is not usually difficult to push down from above.

d. Opening Floors. Permanent-construction wood floors are laid double on joists set on 16-inch centers. The subfloor is laid at a 45° angle to the joists; the finish floor, at right angles. In mobilization-type buildings, a single floor is laid on joists on 16-inch centers. In theater of operations type construction, a single floor is laid on joists on 2-foot centers. Floors can be opened much the same way as a flat roof, except that two distinct cutting jobs are required for double floors because finish floor and subfloor run in different directions. Joists are located by sounding, and both cuts follow the side of the joist toward the required opening. For efficient cutting, the hand which applies the force is held halfway up the ax handle; feet are spread for good balance. The cutter stands outside the area to be opened.

e. Opening Ceilings and Walls (fig. 20). Plastered ceilings are opened by breaking the plaster and pulling off the laths. A pike pole is good for this job. Metal and composition ceilings can be pulled from joists the same way. Board ceilings are hard to remove because the pole cannot be pushed through to get a purchase for the hook. The following precautions must be observed:

(1) Do not stand under the area to be opened.

(2) Pull down and away to avoid being hit by falling material.


Figure 22. Breaking window glass with ax.

(3) Keep the upper hand on top of the pole to aid in pulling away.

(4) Always wear a helmet when pulling down a ceiling.

f. Opening Skylights (fig. 21). Skylights are generally in a metal frame that slips over a flanged roof opening. By prying under the edge, the entire skylight can often be pulled loose and removed. If the light cannot be lifted, glass can be taken out by releasing the metal strips that cover the joints and removing the putty.

g. Breaking Glass (fig. 22). Glass in doors or windows is broken easily with the flat side of an ax. The person breaking the glass stands to one side and strikes the upper part of the glass first so broken glass cannot slide down the ax handle. After the glass is broken out, all jagged pieces are removed from the sash to safeguard personnel, hose, and ropes. This may be done with the pick of the ax.

h. Carrying Tools. Proper procedure in carrying tools is as important as knowing how to use them. Tools with sharp hooks or sharp edges should never be carried on the shoulder; if the fire fighter stumbles, he may release his grip on the tool, which could fall against him or strike another person. Sharp edges and points can best be guarded if tools are held in the hands. An ax is carried as shown in figure 23. In this position it can be easily discarded from the body, and others are protected from its sharp edges. Tools with a hook, such as a claw tool, are carried at the side and with the hook forward. Points of pike poles are shielded.

Figure 23. Proper methods of carrying an ax.

SECTION V

ROPES

13. General

Rope is indispensable in fighting fires, the commonly used type being the hand line. Hand lines for hoisting and anchoring should be ¾-inch rope in 100-foot lengths; they may have an eye spliced in one end. For quick use, a hand line should be coiled so it pays out without tangling, even when dropped from the top of a building. Figure 24 shows a properly coiled line and two methods of carrying it. The rope is grasped with one hand, the loose end is pulled from inside the coil, and the coil is dropped with the eye,

14. Procedure

a Coiling a Line. Figure 24 shows a device for coiling rope. Threads are reamed out of the straight side of the tees so they slip over the pipe. Both tees and pipe are drilled as shown so they can be secured in place with cotter keys. The assembled winder may be secured to a solid object such as a bench or set in a frame, and the coil wound as follows:

(1) Start with plain end of the rope and wind it around standards in order shown in figure 24 until only enough rope is left to complete the coil. This amount can be determined accurately only through practice.

(2) Coil rope in crosswise direction by turning the crank, lapping the second coil over the first.

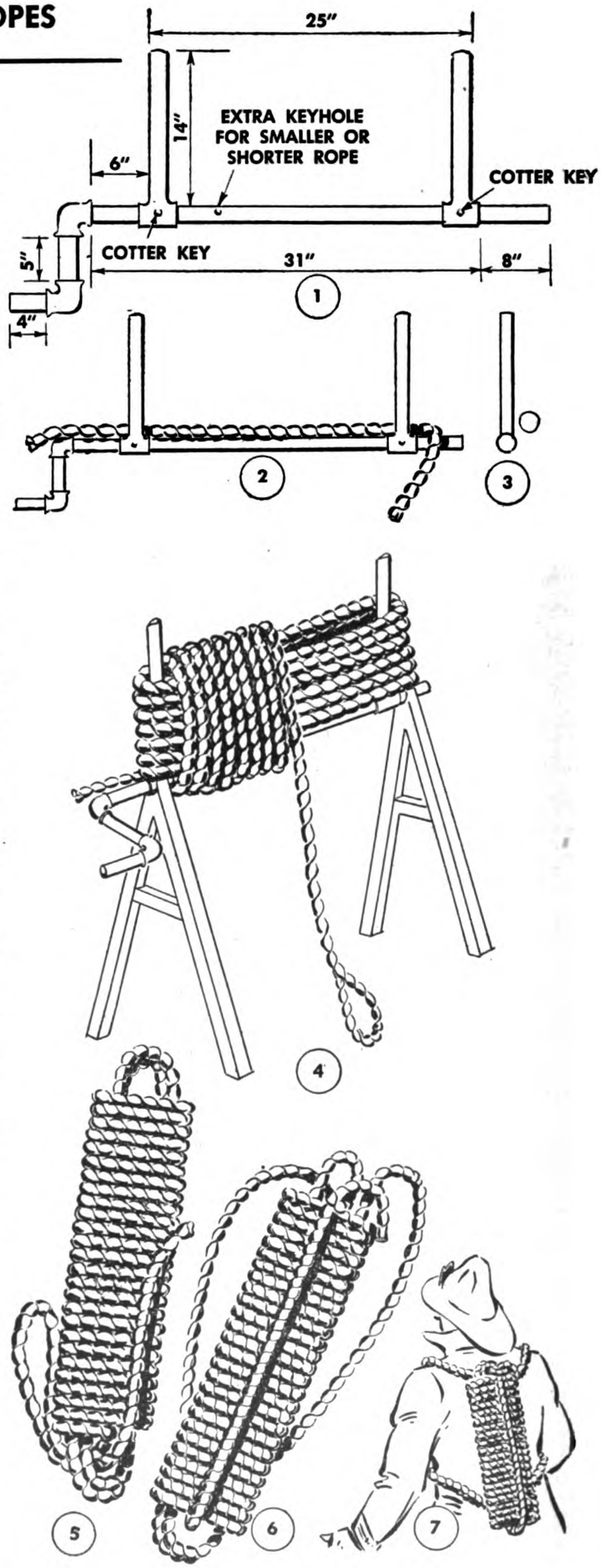
(3) When the opposite end is reached, pull the cotter keys and slip pipe from coil.

(4) Fold free end and slip loop through end of coil.

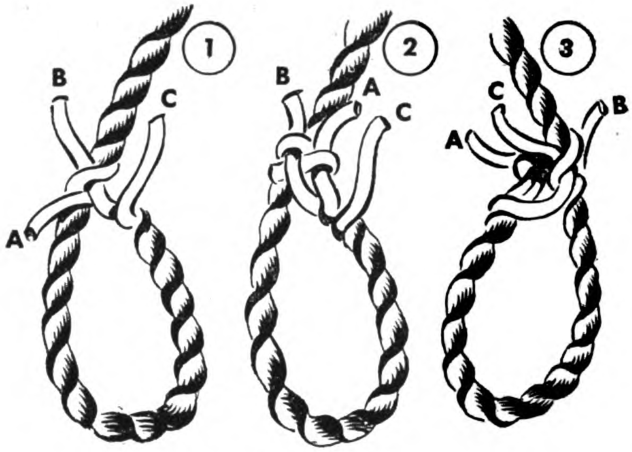
(5) Slip free end through the opposite end of coil and through loop.

(6) Pull loop tight.

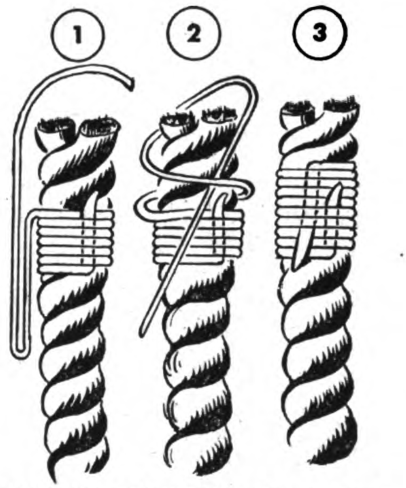
(7) Make loops large enough to load coil on the shoulder. Adjust size by pulling loose end of rope through lock loop.



① *Frame for making coil.*
② *Starting coil.*
③ *Cross section showing position of each turn.*
④ *Coil nearing completion.*
⑤ *Preparing coil to be carried on fire fighter's back.*
⑥ *Completed coil.*
⑦ *Method of carrying.*
Figure 24. Coiling rope.



EYE SPLICE



WHIPPING THE END OF A ROPE

Figure 25. Splicing and whipping.

b. Knots and Hitches. A knot should serve the purpose required, be easily tied and untied in the dark, and be recognizable by another fire fighter in the dark. Rope ends should be whipped to prevent fraying, and eyes may be spliced in both ends of rope. (See figs. 25 and 26.) For fire department use, damaged rope should be replaced, not spliced.

(1) To tie a line to a hand tool such as a pike pole, use the clove hitch which holds securely and does not slip. It should be tied near one end of the pole with a single half hitch around the other end. Figure 27 shows the completed tie and how the same knots can be used for hoisting other pieces of equipment, hose, and tools.

(2) Anchor a rope to a solid object with the chimney hitch, which does not slip and can be untied easily. (See fig. 28.) Use this knot when the strain on the rope is to be constant. Form knot of tight loops for security.

(3) For a loop on the end of a line, use the bowline, which does not slip and is easily untied.

(4) Use the square knot to tie ends of equal-size ropes together and for bandages. Connect ropes of unequal diameters with the becket bend. (See fig. 29.)

(5) Because of their shape, axes are difficult to secure with a hand line. Figure 30 shows a single-loop ax hitch and a double-loop hitch, use when the rope has no loop. Secure loose end of line in double hitch on ax head and a single half hitch on end of handle.

(6) Figure 31 ① shows a method of tying to a ladder for hoisting it. Make hitch about one-third length of ladder from top. After end of rope is passed around beams of ladder as shown, throw loop into line and pass free end through it, making a bowline. When knot is pulled tight and stretched over cross rope, ladder is secure for hoisting. Figure 31 ② shows a variation of bowline for hoisting a ladder. Make bowline loop in end of rope, pass-

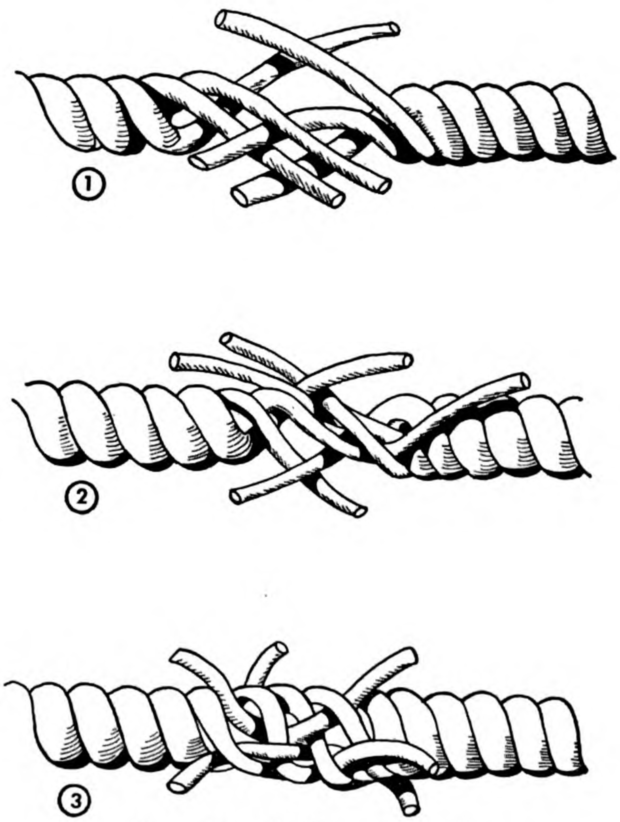
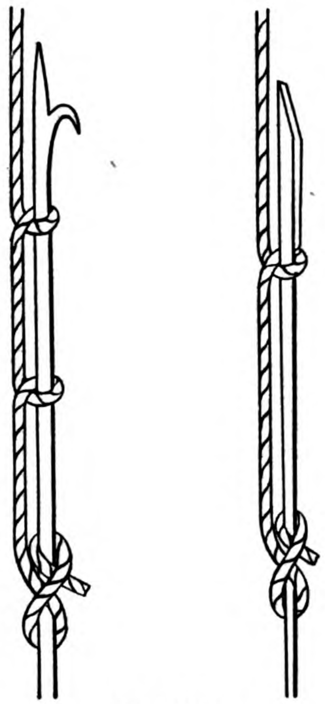
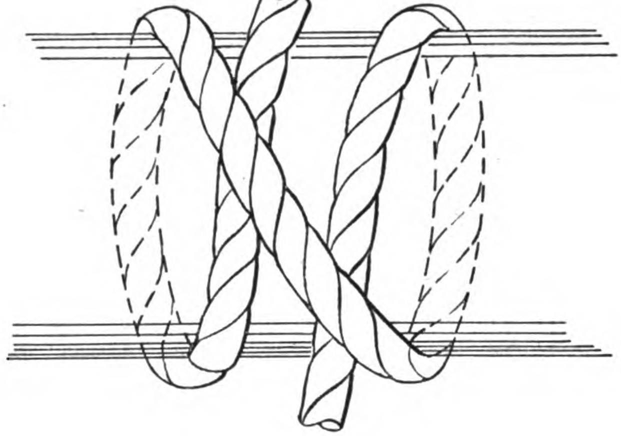


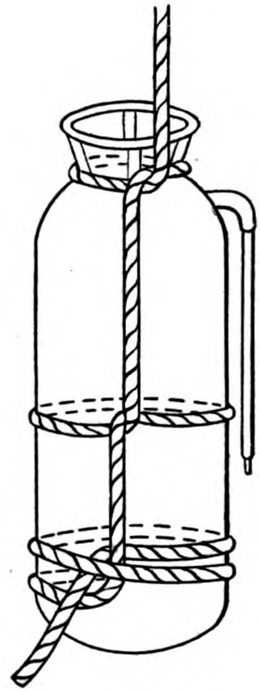
Figure 26. Making a short splice.



POLE HOIST



CLOVE HITCH



EXTINGUISHER HOIST

Figure 27. Hitches used for hoisting equipment. Heavy end of bar and pointed end of pike pole are uppermost.

Figure 28. Chimney hitch used to secure rope on which constant strain is placed. Rope can be shortened or lengthened by slipping knot.

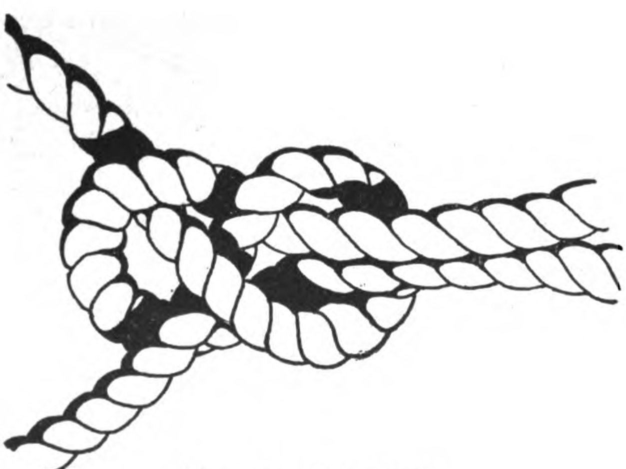


Figure 29. Becket bend.

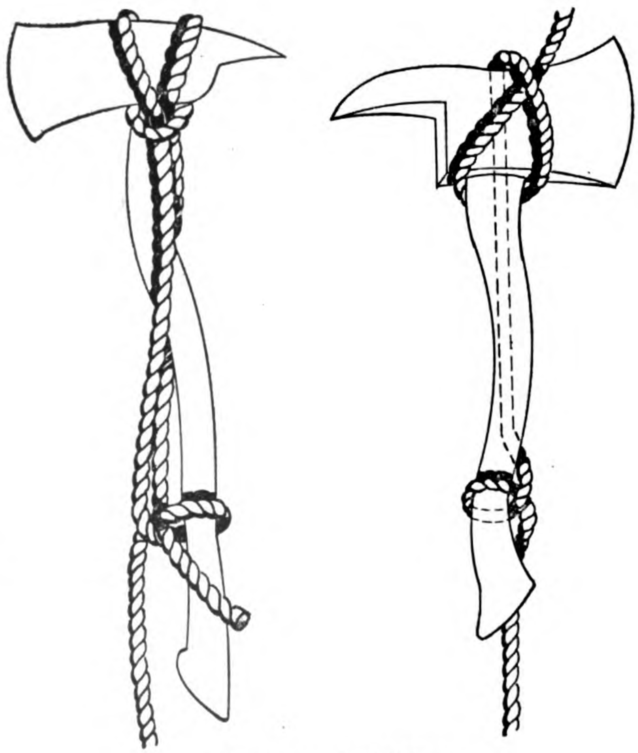
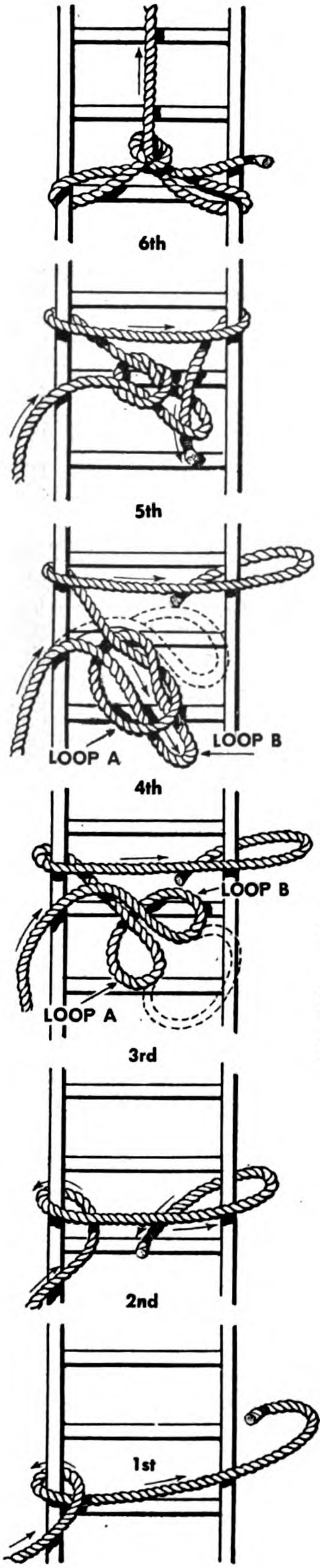
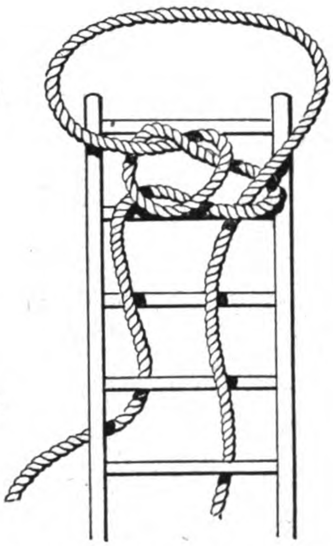


Figure 30. Ax hitches

ing loop through ladder under proper rung and over end of ladder. This tie can be made in the dark more easily than the other.

c. Rope Hose Tool (fig. 32). The rope hose tool is made of about 10 feet of ¾-inch manila rope and a 16-inch length of ½-inch cold-rolled steel. Before making the splice, make four complete twists opposite to the direction of the twist in the rope to secure a perfect loop when the splice is finished. The rope hose tool can be used as a belt for anchoring to ladders, anchoring nozzles or ladders, carrying hose, and many other jobs.





① *Six steps in making ladder hoist.*
② *Variation of bowline for ladder hoist.*
Figure 31. Hoisting ladders.

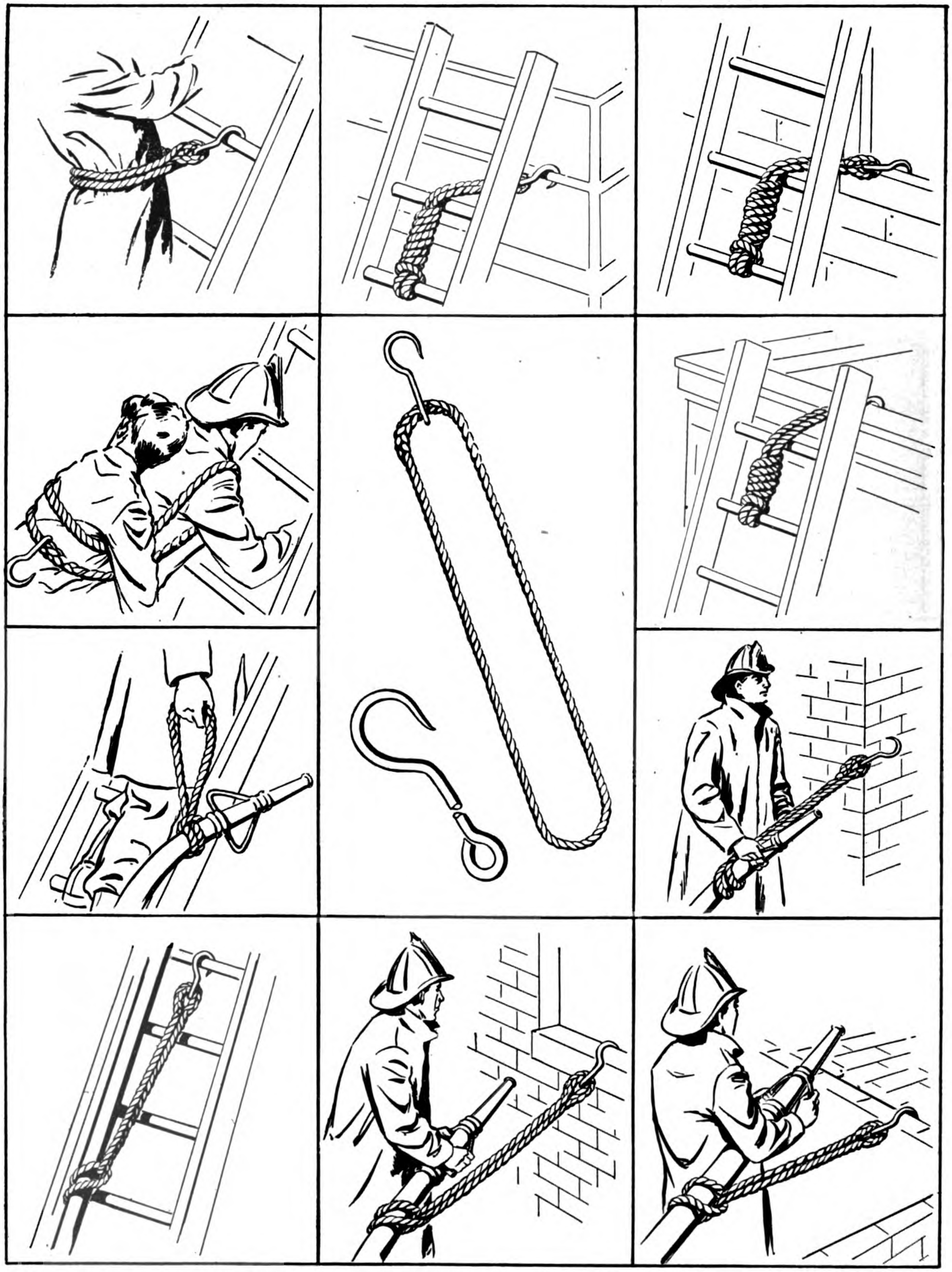


Figure 32. Rope hose tool, detail of hook, and suggested uses. Eye of hook should be welded for greater security. Rope loop should be about 3 feet long.

SECTION VI

LADDERS

15. General

Ladders are generally used in an emergency when every second counts; therefore, fire fighters must know how to carry, raise, and climb them most efficiently. Practice is necessary to make these operations as nearly automatic as possible.

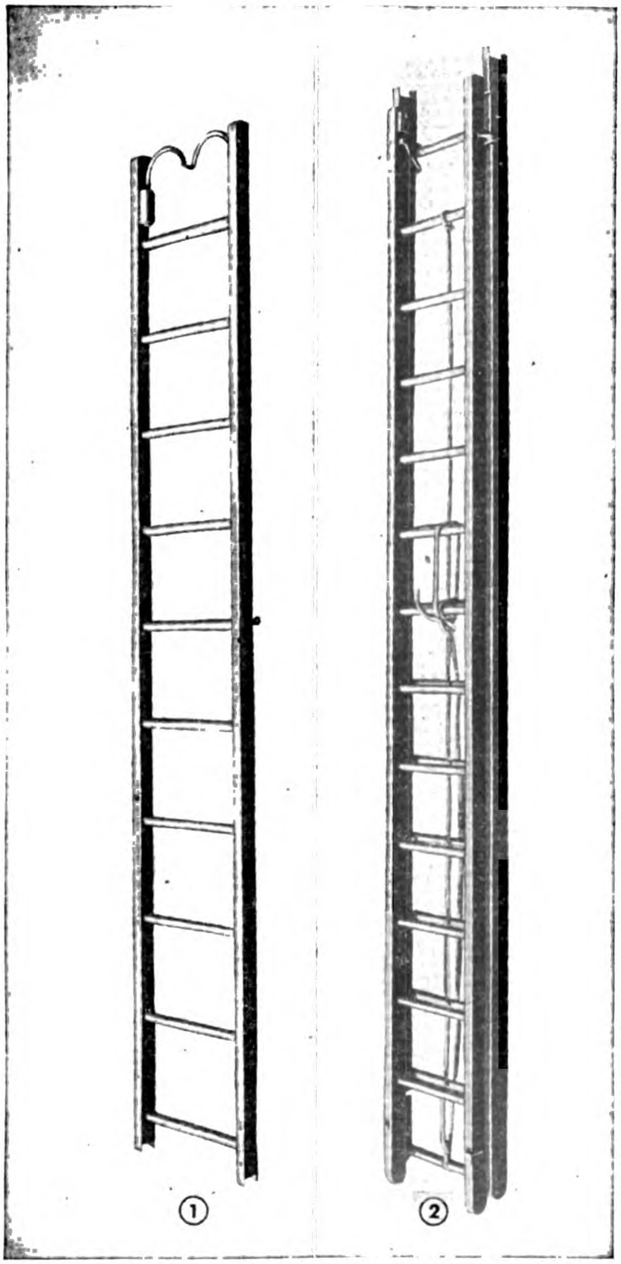


Figure 33. Standard fire ladders supplied to Army installations.
① Roof ladder, 14-foot.
② Extension ladder, 24-foot. The 24-foot ladder has two 14-foot sections with 4-foot overlap.

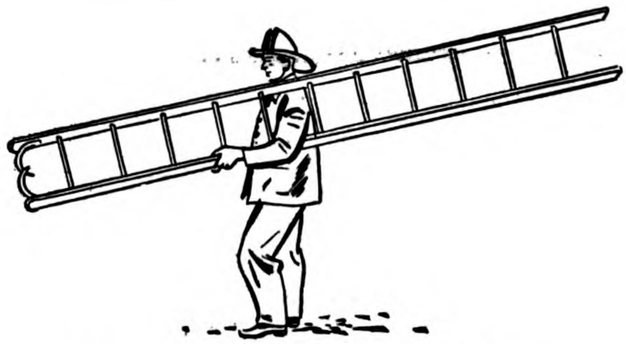


Figure 34. One-man carry for short ladder.

a. LADDER NOMENCLATURE. The standard ladders supplied by the Corps of Engineers (fig. 33) have solid beams, with rungs set in the beam's center. The following terms are commonly applied to ladders:

(1) Bed ladder, lowest section of an extension ladder.

(2) Fly ladder, top sections of an extension ladder.

(3) Butt, ground end of a ladder.

(4) Heel, extreme ground end of ladder beam.

(5) Halyard or fly rope, rope used for raising fly.

Figure 35. One-man ladder raise.

(6) Pawl or dog, mechanism on lower end of fly that locks it to the bed ladder.

b. TYPES. (1) *Extension ladder.* Extension ladders consist of a bed ladder and one or more fly ladders. The fly ladder, sliding through guides on the upper end of the bed ladder, has locks that hook over the rungs of the bed ladder. The fly is usually raised with a halyard fastened to the lower rung that operates over a pulley on the upper end of the bed. The 24-foot extension ladder is the type commonly found on pumpers.

(2) *Straight ladder.* Straight ladders, or wall

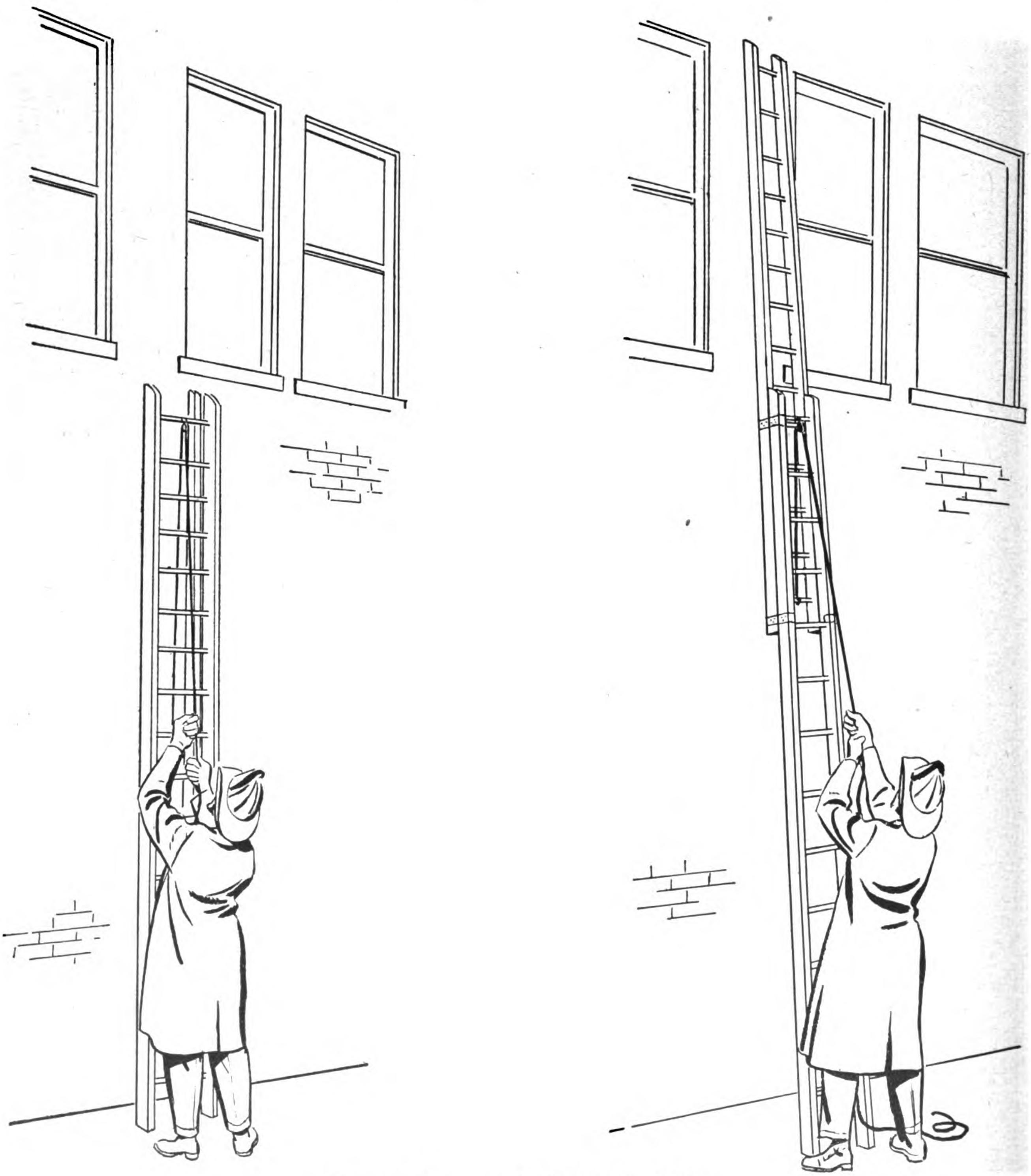


Figure 36. One-man raise for extension ladder.

ladders have one section. They range in length from 12 to 16 feet, the most common size being 14 feet.

(3) *Roof ladder.* The roof ladder is a wall ladder adapted for a special purpose. Roof ladders usually have hooks mounted on a movable socket, which permits them to fold inward when not in use. Placing the hooks over roof peaks, sills, walls, or the coping of any opening makes the ladder safe and reliable whether the but rests upon a foundation or not. With the hooks set so they do not protrude beyond the ladder beams, the ladder can be used as a wall ladder. The roof ladder is used when pitch of roof or weather conditions might endanger the safety of men. It is valuable in getting to peaks of gabled roofs to facilitate removal of shingles or to cut holes for ventilation. It can also be used to enter scuttle holes or holes cut through flooring and sidewalk openings.

16. Procedures

Ladder-handling procedures given in this manual are limited to ladders commonly found on an Army type pumper and to extension and roof ladders.

a. Straight Ladders. Short straight ladders 16 feet or less can be handled safely by one man. Procedure for handling a short ladder by one man follows:

(1) *Securing.* Lift ladder shoulder high and place arm through it near center for balance. (See fig. 34.)

(2) *Carrying.* Carry ladder on shoulder by grasping a rung or beam with the hand that is through the ladder, leaving one hand free. Tilt front of ladder down to give clear vision and prevent catching on overhead obstructions.

(3) *Placing.* Place butt of ladder against building or other secure object.

(4) *Raising.* Raise ladder to a vertical position with both hands by walking toward foot, grasping every other rung. (See fig. 35.) Grasp ladder by rungs with hands about three runs apart and set it at a climbing angle. Placing the butt one-fourth the length of the ladder from the building is a good general rule.

(5) *Lowering.* To lower the ladder, reverse above operations.

b. Extension Ladders. (1) *One-man raise.* Extension ladders no longer than 24 feet can also be carried and raised by one man. (See fig. 36.)

(*a*) If ladder is on the ground—

1. Place ladder with fly down.

2. Face top of ladder, about one-third the distance from the top.

3. Raise ladder above shoulder level, turning it on the beam and lowering it to the shoulder.

4. Slip shoulder forward until ladder balances. Level ladder on shoulder and brace it by grasping upper beam or rung with hand of carrying arm, leaving the other hand free.

5. At desired location, lower butt of ladder against building and raise to a vertical position. Keep fly next to building by pivoting ladder on beam if necessary.

6. Place one foot on ground with knee against beam to steady it. Grasp halyard, keeping top of ladder toward building to balance it. Raise fly.

7. When fly is raised, move bottom of ladder until distance from bottom of ladder to building is about one-fourth the length of the ladder.

8. To lower ladder, place one foot on bottom rung to steady it, bring ladder to a vertical position, and reverse operations.

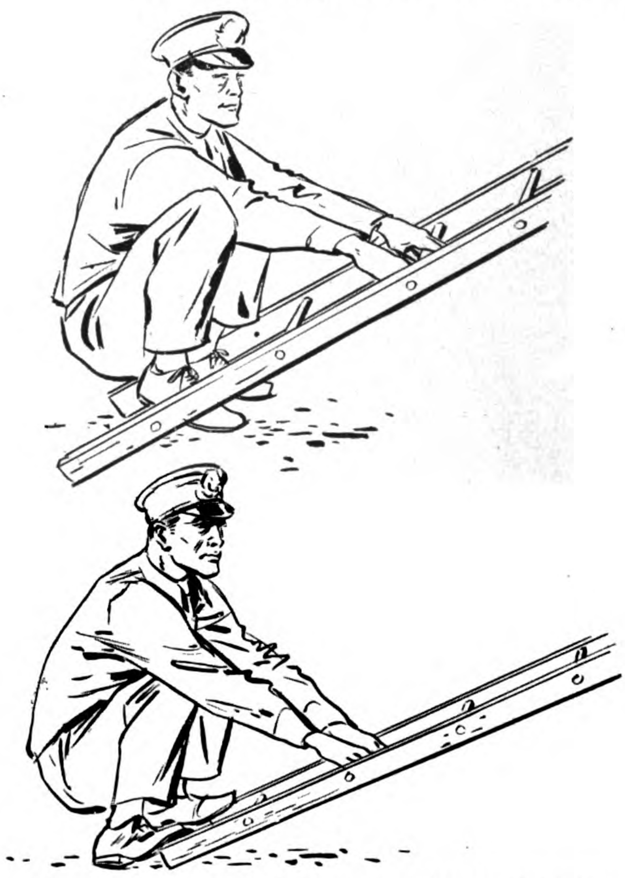
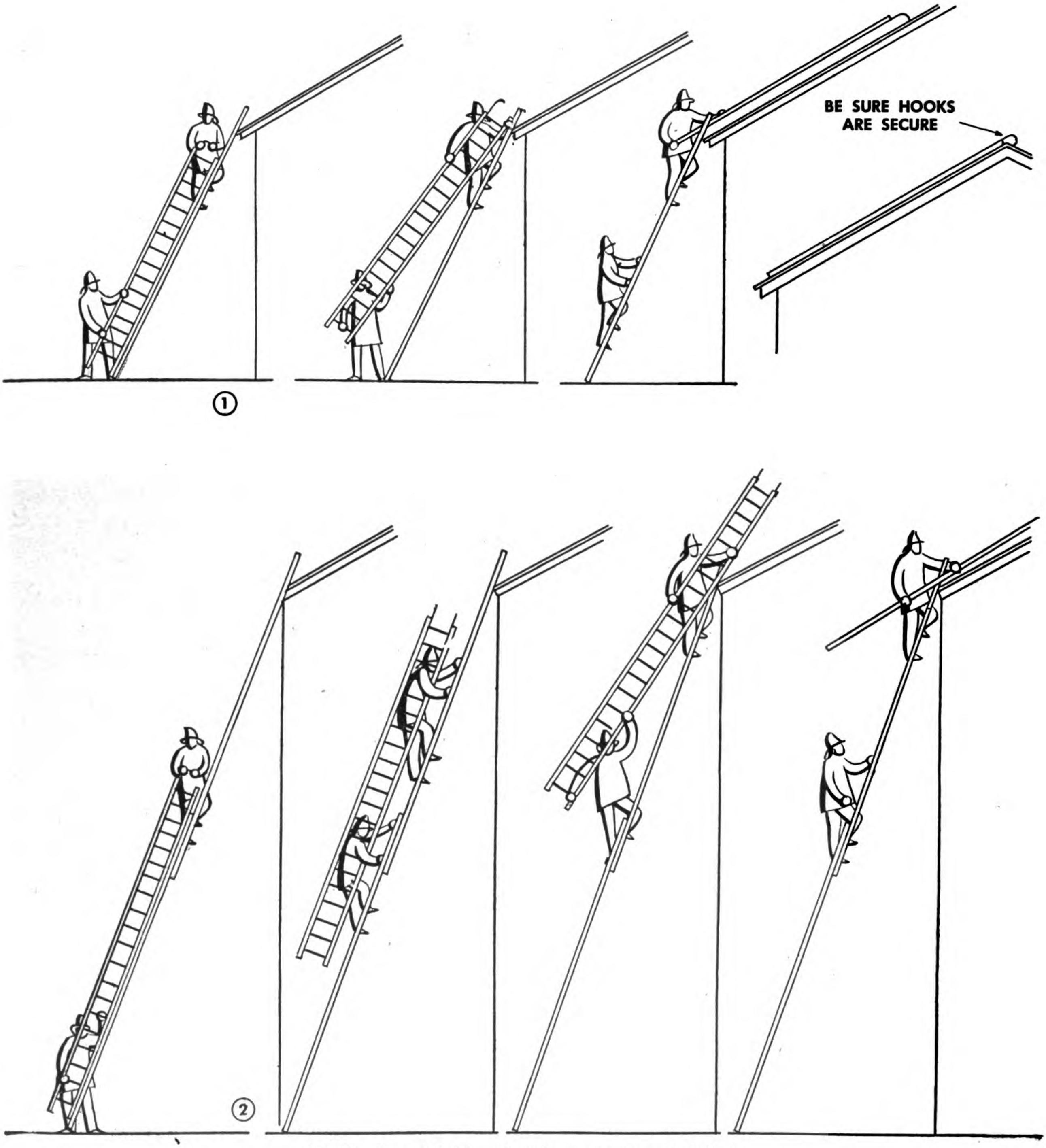


Figure 37. Two methods of footing ladder for two-man raise.



① *Short roof ladder placed on one-story building.*
② *Longer roof ladder placed on two-story building.*
Figure 38. Placing roof ladders.

(*b*) If ladder is on a truck or hangers, set the shoulder at center of ladder and lift it directly to the shoulder.

(*c*) If ladder is to be set on concrete, place heel of ladder against building or other object. Set it at desired distance before raising fly.

(*d*) If ladder is to be placed in a window, place it at one side, not in the center, so hose taken through window does not cross ladder.

(2) *Two-man raise.* When two men raise the ladder, one man stands at the heel and the other towards the top. The man heeling the ladder can help by throwing his weight back to balance the ladder; he should crouch, always watching the top

of the ladder. (See fig. 37.) When raising the fly, the inside man steadies the ladder while the outside man raises the fly. The beam raise is another two-man method of raising a ladder. Place ladder on beam. One man places a foot on lower beam heel, grasping the upper beam with both hands; the other man stands beside ladder facing the top. Grasping a rung with the hand nearer the ladder, he raises it shoulder high and under it. With both hands grasping the lower beam, he walks the ladder up. The fly ladder must be kept next to the building.

c. Roof Ladders. (1) Figure 38 shows position for carrying the roof ladder, the top end ahead and lower than the shoulder for safety. For one-story buildings, the man using the roof ladder is at the building eave. When the top of the roof ladder is raised to him, he opens the hooks and slides the ladder to its place on the roof.

(2) If a two-story building is involved, the man on the ladder takes a position where he can reach the top of the roof ladder and both men carry the roof ladder up until the top man reaches the eave where he locks in and proceeds as before, the second man assisting as shown. To lower the roof ladder, the operations are reversed.

d. Climbing. Two factors in climbing are rhythm and safety.

(1) Obtain proper rhythm by taking every rung with the feet and every other rung with the hands.

(2) Keep one hand on the rungs. When carrying something with one hand, slide it along the beam. Place feet at the center of the rung to prevent wobbling; carry body nearly upright by keeping arms straight. Use ball of foot in climbing. Climb steadily and smoothly; *do not run.*

(3) Figure 39 shows method of locking in on a ladder. Keep locking leg opposite to side where work is done, placing other foot against beam. This method leaves both hands free to handle hose, ladders, and tools. Anchor to ladder with a rope hose tool or a safety belt only when one position must be kept for some time.

e. Anchoring Ladders. For safety, a ladder

Figure 39. Methods of locking to a ladder. Short men should lock foot around rung; tall men, around beam.

should be anchored to the building with a rope hose tool, hose chain, or strap. (See fig. 40.) The anchor prevents the ladder from vibrating, slipping or turning over when load is shifted.

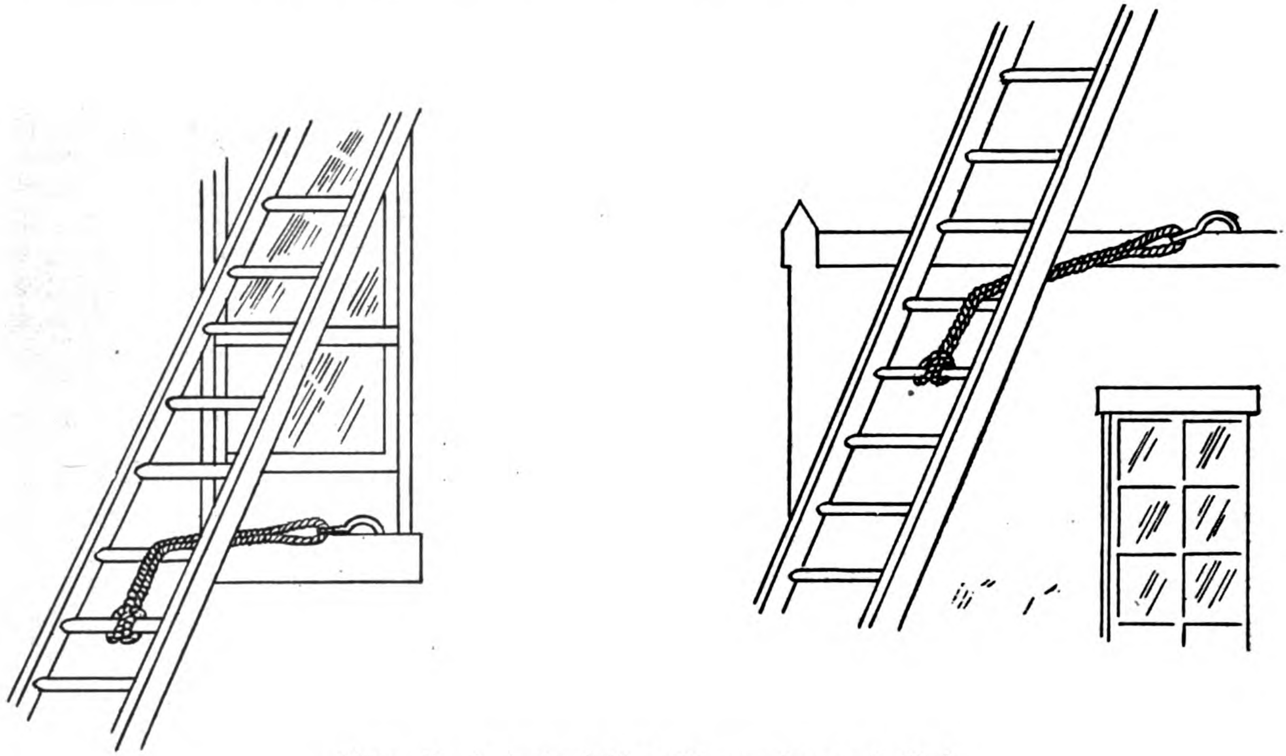


Figure 40. Anchoring ladder with rope hose tool. Slack must be taken from rope by twisting or taking extra turn around rung.

SECTION VII

FIRE HOSE

17. General

Fire hose must be flexible, watertight, and durable. Fire fighters must know hose construction and the various types used before they can use it efficiently or care for it properly.

18. Types

Three types of hose are used for fire fighting. They differ in diameter and construction to meet the requirement of specific uses. All fire-hose threads must conform to the Table of National Standard Fire Hose Thread unless specific authority is given for variation. The following types are supplied by the Army.

a. Cotton-Jacket, Rubber-Lined Hose. Cotton-jacket, rubber-lined hose is supplied in four sizes, 1½, 2½, 3½, or 4 inches.

(1) Cotton-jacket, rubber-lined hose in 1½- or 2½- inch sizes is commonly used to carry water under pressure from the source of supply to the fire. It may have either a single or double jacket of the best grade of cotton to resist scuffing or abrasions and withstand high pressures required in fire service. The rubber lining may be an extruded, seamless-rubber tube or cemented, lap-jointed, calendered sheets. Lining is constructed so the passage of water meets minimum resistance to reduce friction loss. The hose comes in 50-foot lengths; couplings are brass or malleable iron with pin or rocker lugs.

(2) Double-jacket cotton, rubber-lined hose is tested at time of manufacture to 400 pounds per square inch (psi). However, field-service tests to insure emergency operation must be made in accordance with TM 5-687. Pressure over 200 psi must never be imposed during tests on this type hose.

(3) Single- or double-jacket cotton, rubber-lined hose of 1½-inch size is used for hose complement with class 300 brush trucks, class 325 fire trucks, on standpipe lines, and sometimes for leader lines on pumpers. Use of 1½-inch hose for leader-line equipment is specifically authorized when local conditions warrant.

(4) Single- or double-jacket cotton, rubber-lined fire hose of 2½-inch size is used for hose complement with class 500, 525, and 750 pumpers and on hand-drawn hose carts.

(5) Cotton-jacket, rubber-lined hose of 3½- and 4-inch sizes is used as a soft suction hose to connect a fire pump to a hydrant. This hose permits passage of enough water for pump capacity if no sharp bends are present; it is suitable only when enough water pressure is available to prevent collapse. Couplings on both 3½- and 4-inch soft suction hose have 4½-inch National Standard hose threads to permit connection to pump intake without an adapter.

b. Rubber-Covered, Rubber-Lined Hose. Rubber-covered, rubber-lined hose is used for booster lines and hard suction hose. For the latter service, a spirally wound metal reinforcement or metal braid is used to prevent collapse.

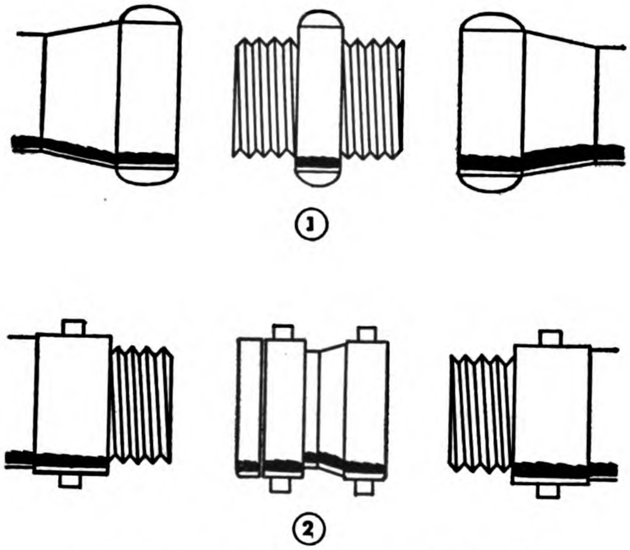
(1) Booster hose has a rubber tube with multiple plies of woven cotton duck or braided-cotton reinforcing bonded together. Over this, a rubber cover protects against wear and abrasion. Usually booster hose has a 1-inch diameter and is made in lengths of 50 or 100 feet. Specifications require a test pressure of 400 psi, but service tests must be made as required in TM 5-687.

(2) Hard suction hose is made in 3-, 4-, and 4½-inch sizes. Lengths usually are 10 feet although some longer lengths are used for a squirrel-tail suction. This hose is required to stand a negative or vacuum pressure equal to 23 inches of mercury.

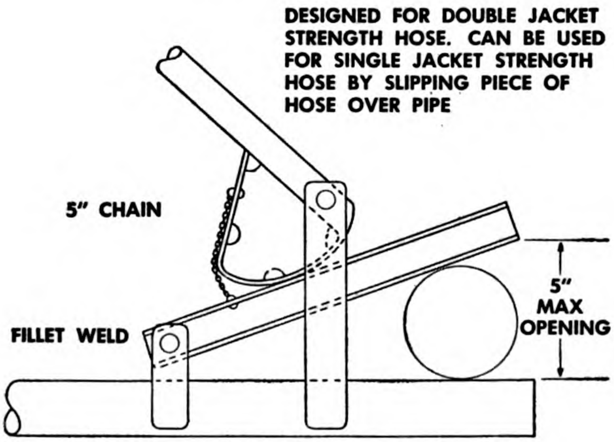
c. Unlined Linen Hose. Unlined linen hose is suppplied in 1½-inch size only; it is made of closely woven linen without a rubber inner lining, the tightness of weave holding the water. Seepage before saturation is normal because linen fibers swell when wet. Unlined linen hose is used where excessive pressures are not encountered, as on standpipe systems; it is suitable where hose is rarely used. This type should not be used for other than its intended emergency purposes.

19. Couplings

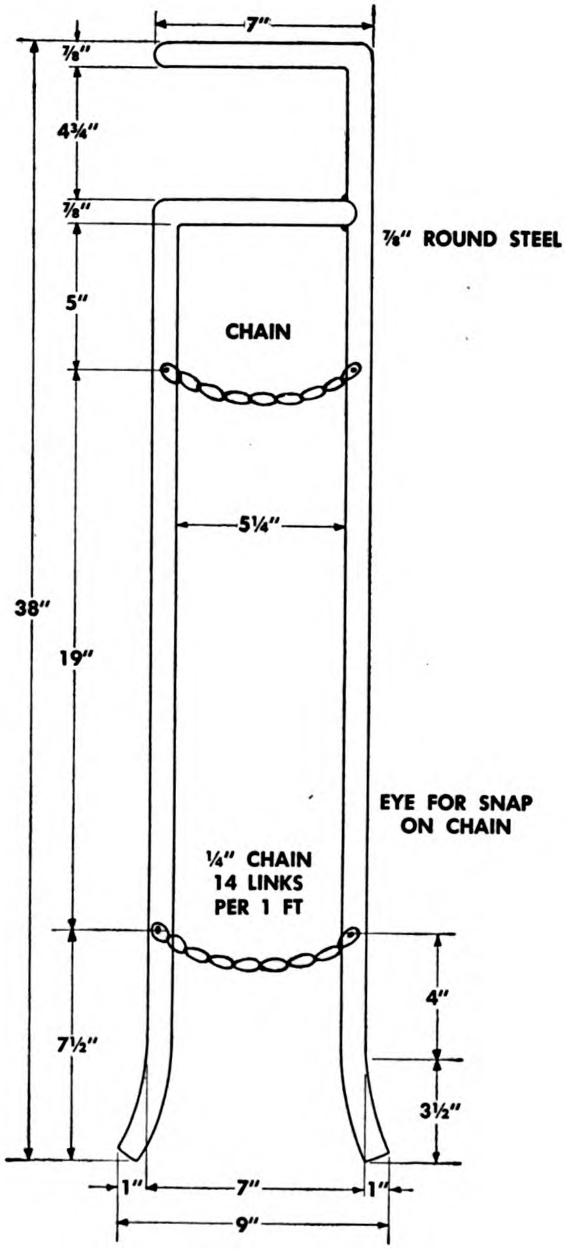
a. General. For convenience in handling and replacement, hose is manufactured in 50-foot lengths which must be coupled together. Couplings must make it possible to connect and disconnect hose lengths quickly and easily. Brass, bronze, or combinations with malleable iron are generally used for couplings during peacetime, but many

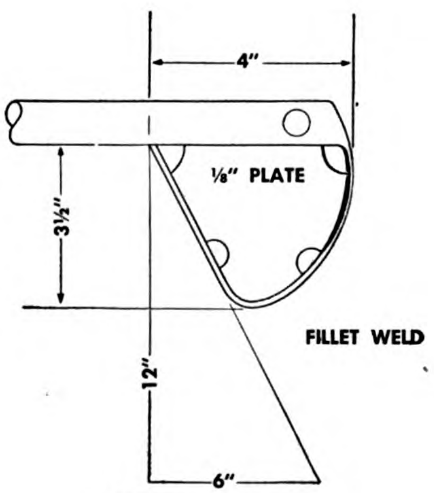


① *Double male connection with rocker lugs.*
② *Double female connection with pin lugs.*
Figure 41. Hose connections.



DETAIL OF CLAMP OPENING





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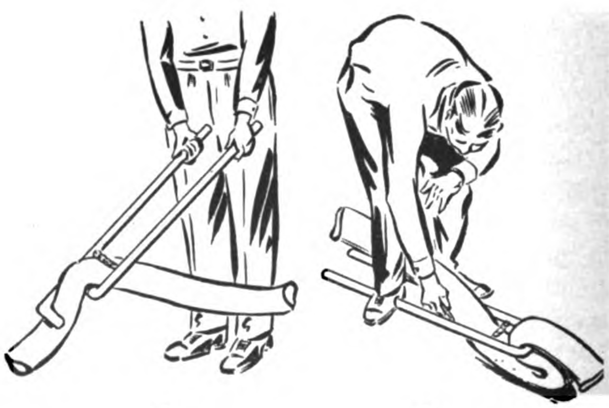


① ②

Figure 42. Type of hose clamp that can be made locally.

hose couplings have been made of malleable iron which requires more careful maintenance and protection during handling. (See TM 5-687.) Because of the dependence placed on fire hose during an emergency, all hose couplings must be handled carefully.

b. Types. Several types of couplings are used in the fire service; the most common are described below.

(1) The three-piece coupling has male and female thread ends. The female thread is in the movable part of the coupling, flanged on the immovable part that is fastened to the hose. A gasket fits snugly inside the female end of the coupling.

(2) Pin-lug and rocker-lug couplings have the same internal construction and use. The difference is in the lug. Since the lug affords a hold for the spanner wrench, its design must meet this requirement without hindering manipulation of the hose. The rocker-lug coupling offers less hindrance than the pin-lug in passing hose over or around obstructions.

(3) Suction-hose couplings have extended lugs which are helpful in connecting the hose. Their general construction is the same as for regular couplings.

20. Appliances

If fire fighters are to use all available equipment to the best advantage and produce desired fire streams in the shortest possible time, they must have varoius hose appliances at hand and know how to use them. Common appliances include—

a. Double male connection (fig. 41 ①), used for connecting two female ends of hose or appliances.

b. Double female connection (fig. 41 ②), used for connecting two male ends of hose or appliances.

c. Siamese and wye connections, used respectively for uniting and dividing two lines of hose. They may be used on hose of equal or unequal size.

d. Nozzles, metal appliances used to direct and control the fire stream. A shut-off nozzle has three sections: play-pipe stub, controlling valve, and tip. Underwriter's play pipe has two section: play pipe and tip. Nozzle tips are removable.

e. Hose jackets, used when small cuts or breaks occur in hose during operation. The jacket is opened and one side placed under the hose at the leak; the upper part of the jacket is then snapped together. It can be used where threads on hose couplings are of different sizes or are badly damaged. As a temporary hose coupling, the two couplings are brought together within the jacket and the jacket closed. Pressure inflates and seals the couplings.

f. Hose clamps, used for shutting off water in lines to replace burst sections of hose, make tap-ins, extend lines, and so on without shutting off source of supply. It is also used when laying a line of hose from the hydrant, allowing the man at the fire hydrant to operate the hydrant without a signal from the company officer at the fire. This speeds operation by having water controlled at the fire. The clamp is placed on the hose about 15 inches from the coupling. It can be used to shut-off a charged line being carried aloft or moved any great distance. Since water in one 50-foot length of 2½-inch hose weighs approximately 105 pounds, draining the hose may save time and effort. Hose clamps may be made locally. (See fig. 42.)

21. Loads

a. General. On mobile apparatus carrying large quantities of hose, the method of loading is a definite problem. Factors to be considered in making a hose load include—

(1) Economical use of available space.

(2) Retaining natural shape of hose by preventing short bends or crushing.

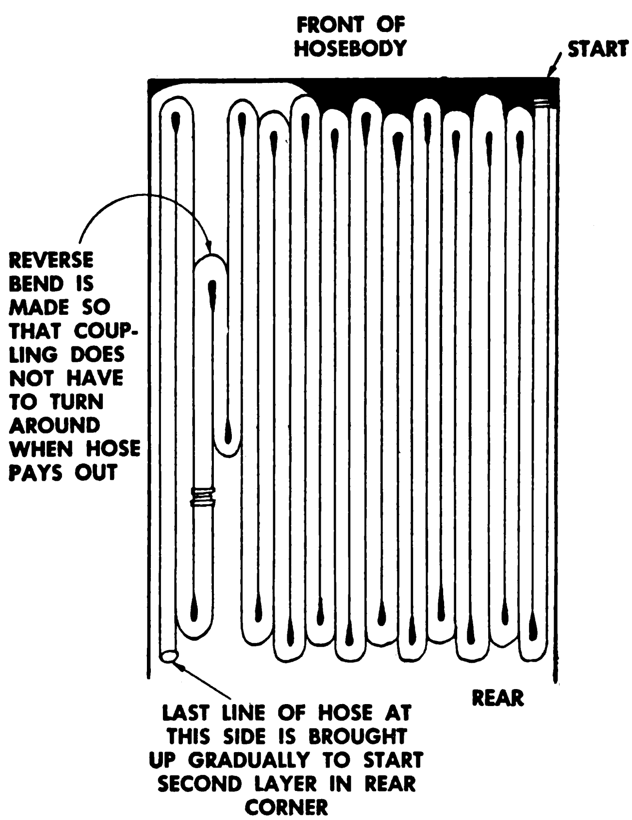


Figure 43. Horseshoe load.

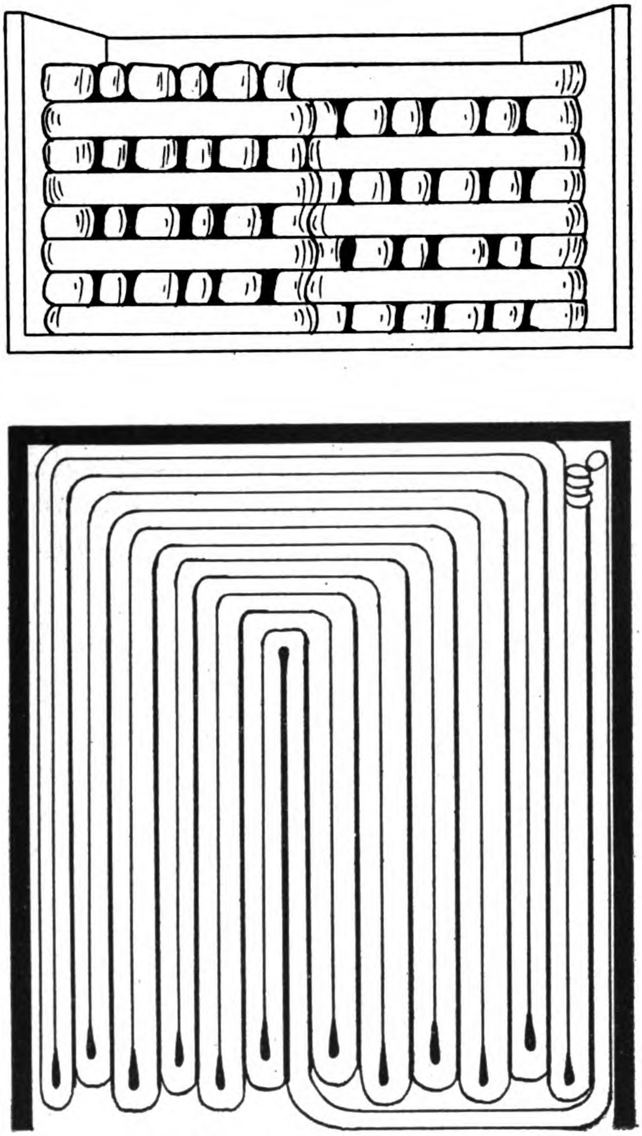


Figure 44. Accordion load.

(3) Ease with which load pays out when making a hose lay.

(4) Ease with which armfuls of hose may be withdrawn from load.

b. Horseshoe Load (fig. 43). The horseshoe load (U-load) most nearly meets the above requirements. It is started in the right corner of the bed. Hose is laid around the inside of the bed with alternate rear folds made shorter so bends do not crowd. Rear bends on the half of the bed around which hose for the next layer passes are 2 inches shorter so the completed load is neat.

c. Accordion Load (fig. 44). Although the accordion load is easy to place in the hose bed and is generally used, all the bends are sharp, tending to cramp the hose's rubber lining. The load is started with the hose end in the right front corner, with the hose folded back and forth across the hose bed. Every other bend is made a few inches shorter than the preceding one so bends are less sharp and paying out is easier. When completing the layer at the side of the bed, the last length is gradually raised from front to rear until at the rear it is on top of the first layer. As each layer is completed, the remaining space becomes narrower than the diameter of the coupling. If the hose is placed in this space so the coupling must turn around in paying out, it will jam. To avoid this, a reverse bend (Dutchman) is made at the coupling as shown. This procedure is also used to avoid placing two couplings in one layer immediately opposite each other.

d. Baffle-Board or Divided Load (fig. 45). Loading hose on apparatus using a partition to divide the load is called the baffle-board load. This method enables one piece of apparatus to lay two lines of hose at one time; it may be used where short lines to heavy streams are required. Some fire departments make one side of the load a continuation of the other side so a single long line may be used if desired; this is done by loading the left compartment first and then carrying the line around the rear of the partition to begin the other load. When a single line is needed, the hose is run from the right compartment; when two are used, the coupling joining the two sides is first disconnected.

(1) The divided hose body makes possible carrying one side loaded to lead off with the female coupling for a hydrant-to-fire lay and other loaded to lead off with the nozzle for a fire-to-hydrant lay. The two loads may be joined by a double connection.

(2) Where $1\frac{1}{2}$-inch hose is used, carrying two lines connected to a wye but not connected to the $2\frac{1}{2}$-inch line is an advantage. The divided hose body makes this combination convenient.

22. Hose-load Finish

To save time and to insure having enough hose either at the hydrant or at the fire, the hose load is finished so that enough of it to do all that may be expected can be easily dumped.

a. Doughnut Load. The doughnut-roll finish is good practice when laying from hydrant to fire. Figure 46 shows how the roll is made in place on the hose load. The man catching the hydrant grabs the loose end of the roll and steps off the truck, sliding the entire roll with him. As it unwinds, the

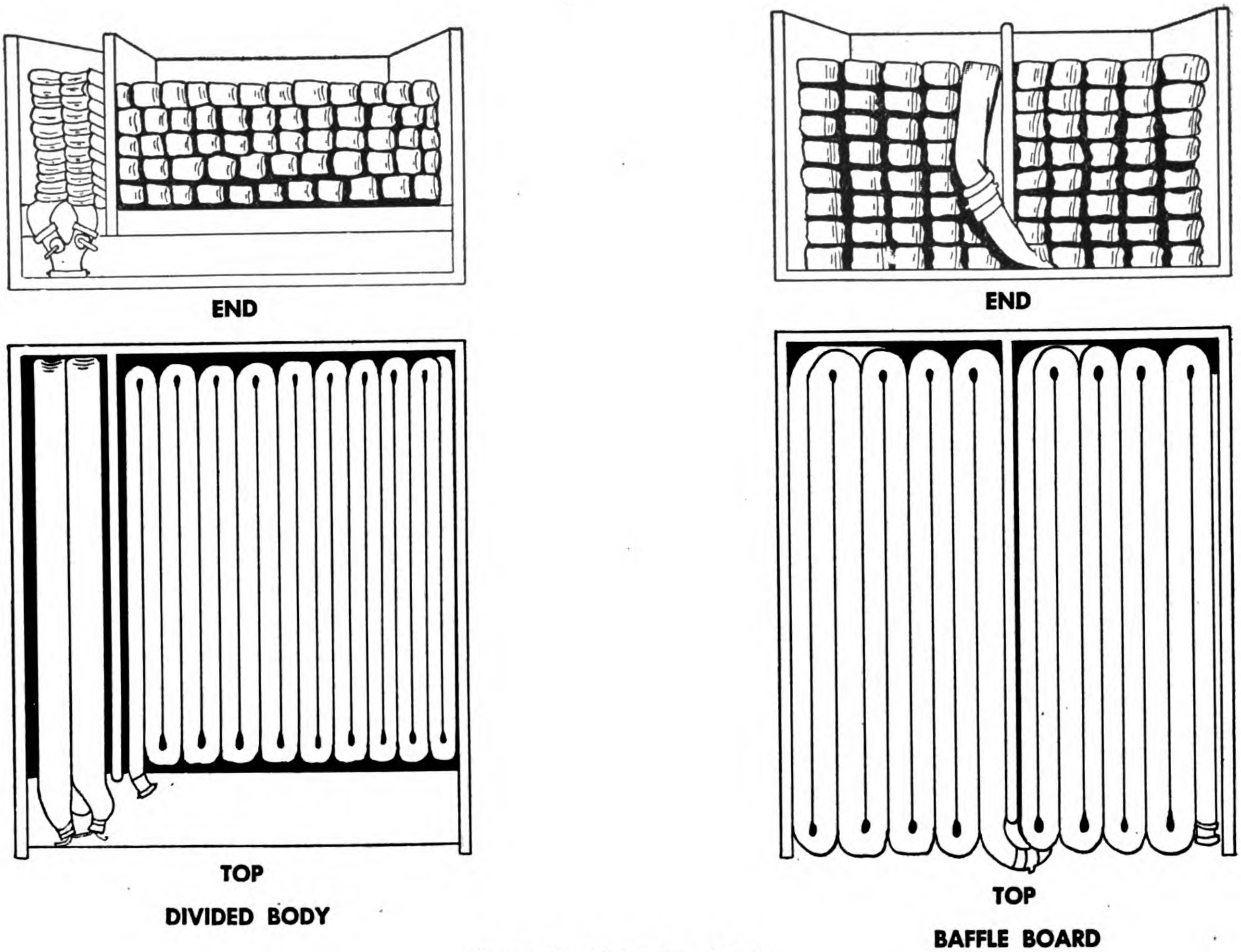


Figure 45. Baffle-board load.

end to the hydrant is extended enough to make connection easy.

b. Skid Load. Figure 47 shows the skid load, used when hose is laid with nozzle out and lay is made from fire to hydrant. About 125 feet of hose is used for the skid load, all placed above a level lower layer, free from protruding lugs and with its last folds fairly loose.

(1) Starting at front end of body, put in a few cross folds.

(2) Make a pair of skids with 8-inch overhanging handhold loops.

(3) Lay cross folds on skids with plenty of clearance at each side and with couplings riding on skids.

(4) Place nozzle on top of all.

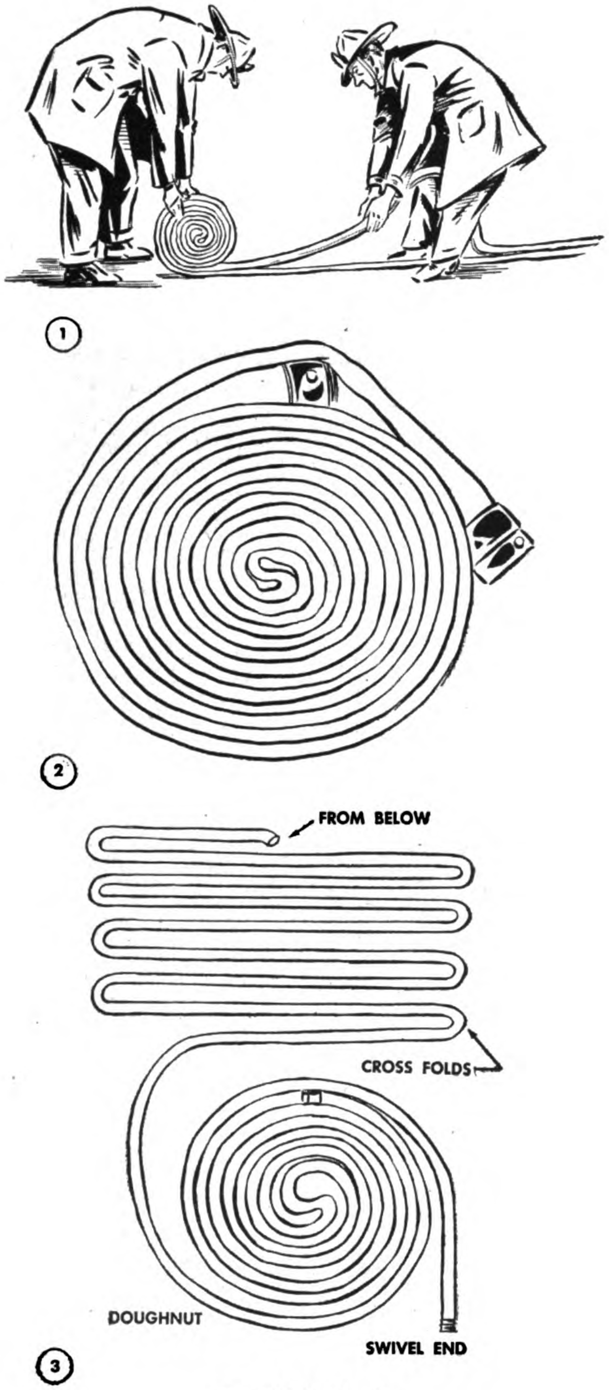
(5) When truck stops at fire, pull off load by pulling on skids. This makes over 100 feet of free hose available. Its weight on the ground unloads other hose as truck proceeds to hydrant. This finish load can also be used with 1½-inch hose to a great advantage.

c. Riprap Load. The horseshoe or U-load is sometimes difficult to start unloading because of friction and tightness of folds. To insure easy running of enough hose to make the plug connection, the riprap load finish is used. Figure 46 shows the hose arrangement, cross folds lying loose enough to run off easily and give the plug man time to secure the hose.

23. Lay-Outs

Although hose can be loaded at leisure, time is at a premium in making hose lay-outs and advancements must be done quickly with the keenest skill and cooperation possible. Two definite hose lay-outs are recognized as good practice, straight lay and reverse lay, described below. The fire department must practice these procedures thoroughly until they are perfected.

a. Straight Lay (fig. 48). The straight lay is from hydrant to fire. The truck slows down at the hydrant, drops off the plug catcher, and proceeds



① *Making load.*
② *Completed load.*
③ *Riprap finish.*
Figure 46. Doughnut load.

to the fire. Since hydrant pressure is used entirely, the truck remains at the fire where all its equipment is accessible.

b. Reverse Lay. When pumpers are used, the truck must be located at the hydrant, requiring a reverse lay from fire to hydrant. Keeping a double female connection on the male end of the hose and a double male on the nozzle is good practice. If a reverse lay is made, the nozzle is ready to attach; if a straight lay is used, the double male can be removed and the nozzle connected directly. This is done because unscrewing a double connection is easier than getting one from the truck.

(1) Fire fighters must know their loads and the ways of adapting them to the situation to avoid serious delay.

(2) All men must not leave the truck at the fire. One man should remain to assist the driver to make hydrant or pump connection. Since the truck must remain at the hydrant, all necessary tools should be unloaded at the fire.

c. Straight-to-Reverse Lay (fig. 49). If getting apparatus near enough to a fire to complete a straight lay is impossible, a straight-to-reverse lay is used. The apparatus is driven as near the fire as possible; the hose is broken and a double female coupling is attached to the lay to receive the male end of the hose when it is advanced. A double male coupling is attached to the open end of the hose on the bed and a nozzle is attached to it. Next, the hose is advanced to the fire and the hose is broken and connected to that laid from the hydrant.

24. Hydrant Connections

a. Types of Hydrants. Several types of fire hydrants are in use, differing somewhat in construction. Most hydrant are opened by turning a valve to the left. The number of turns needed to open a hydrant varies with the make, 12 to 20 turns usually being required. To get full flow, the hydrant must be opened completely. If the hydrant sticks at about 8 to 10 turns, closing the hydrant and then reopening it may be necessary.

b. Markings. TM 5-685 (when published) requires marking fire hydrants with their capacity. In applying markings, capacities of hydrants are determined by fire-flow tests on one hydrant at a time. Markings are made locally as desired. They insure the operator of the first truck only of enough water at the time he makes connection; a thorough knowledge of the post water system is still required of pump operators.

c. Catching Hydrant. While catching a hydrant is a simple operation, a few time-saving points and safety hints must be considered.

(1) The driver should swing close to the curb and slow down enough for the plug man to step off safely.

(2) A doughnut roll on top of the hose load permits control of enough hose for the operation.

(3) The plug man should grasp the hose with the hand farthest from the hydrant, carrying the hydrant wrench in the other. This allows him to run to the hydrant without having hose across his knees.

(4) The plug man steps off the truck about 20 feet before reaching the hydrant, runs directly to the plug and goes halfway around it on the side away from the curb. This permits him to face the hydrant outlet in the best position for fast work and still be clear of the line if it fouls in the bed and whips the hose around the hydrant barrel. The hose should be lapped around the hydrant and held firmly with the foot.

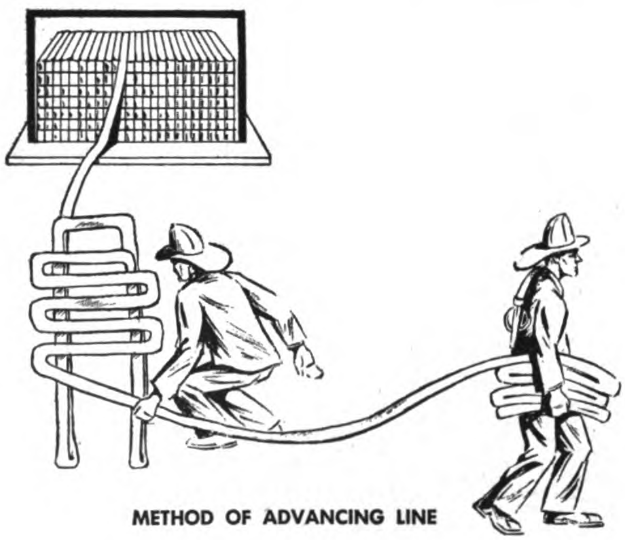
(5) Facing the outlet closest the fire, he puts the female coupling on the ground, keeping his foot on the hose close to the coupling until he is ready to make connection.

(6) The hydrant cap is loosened and the wrench is placed on the operating nut.

(7) The cap is taken off, hose is taken from around the hydrant, the connection is made to the outlet handtight, and the line is charged when the signal is given.

(8) If the connection leaks after water is turned on, it can be tightened with the spanner.

d. Breaking Line. After the hose clamp has been applied, enough hose has been removed, and the proper nozzle selected, the coupling must be broken. Figure 50 shows proper practice in break-



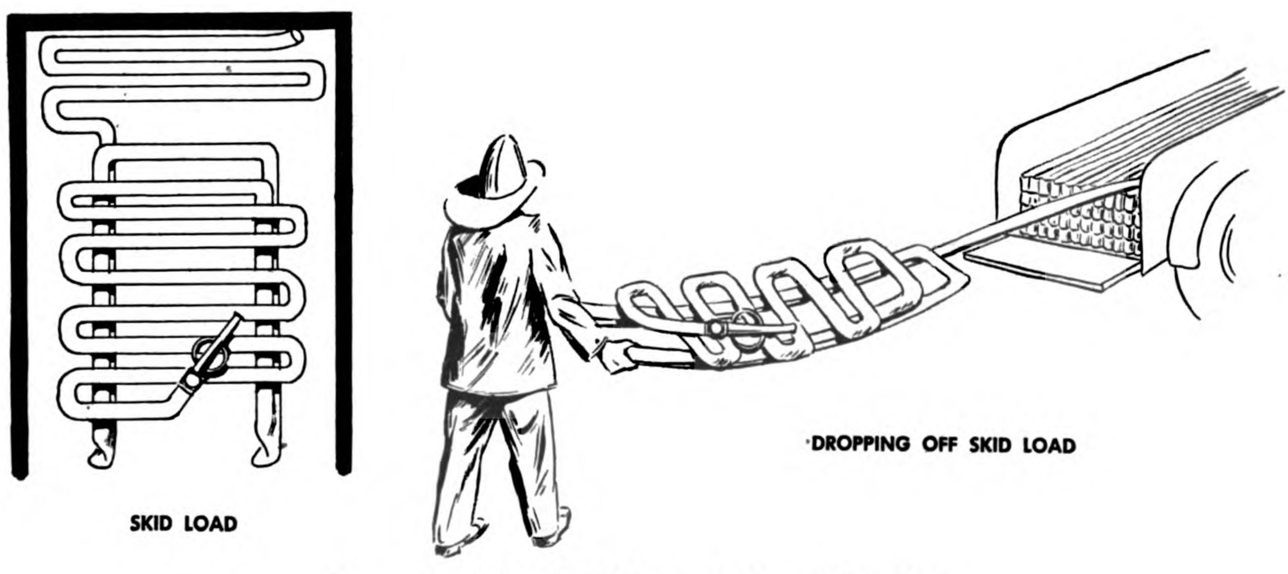
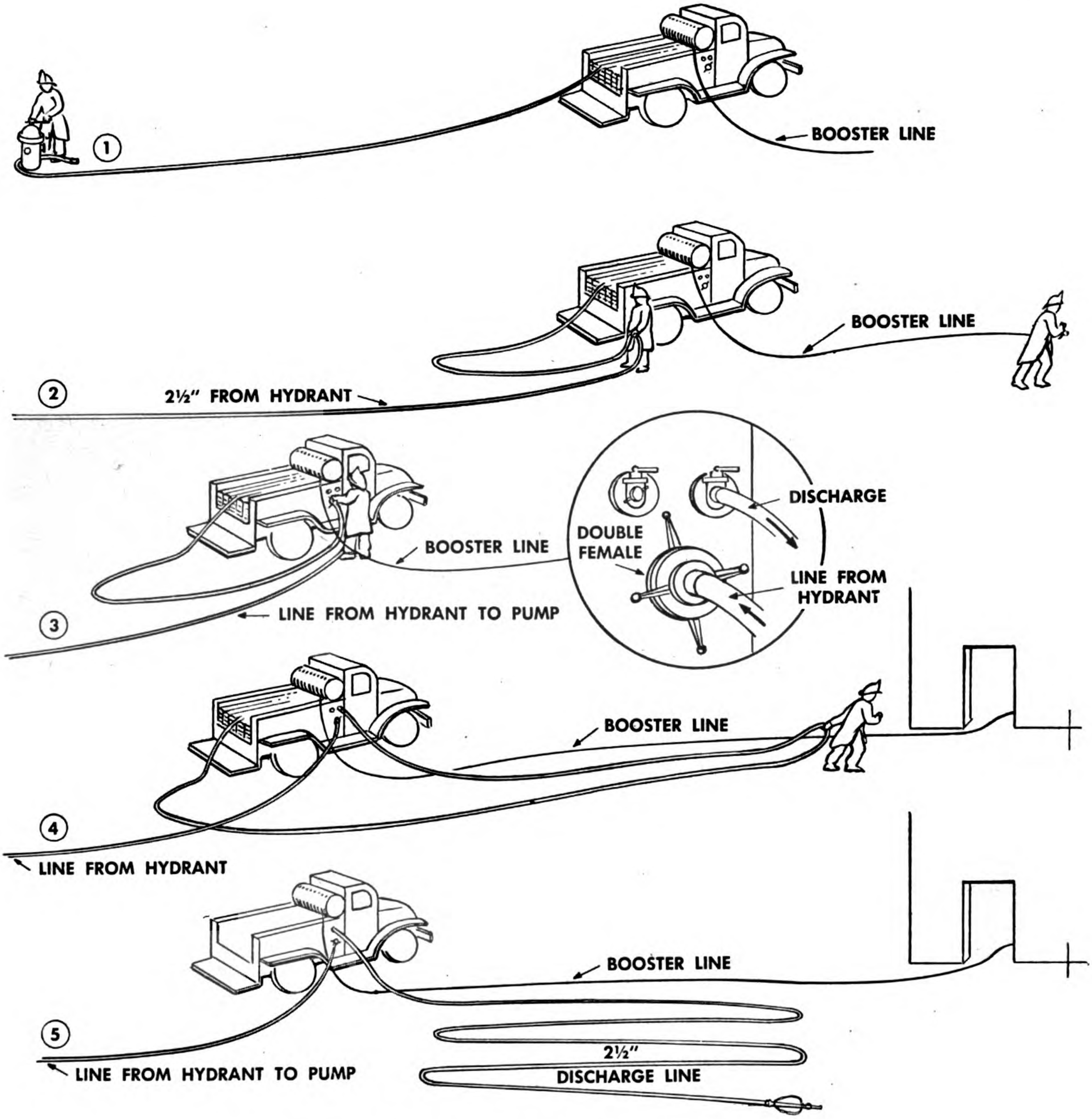
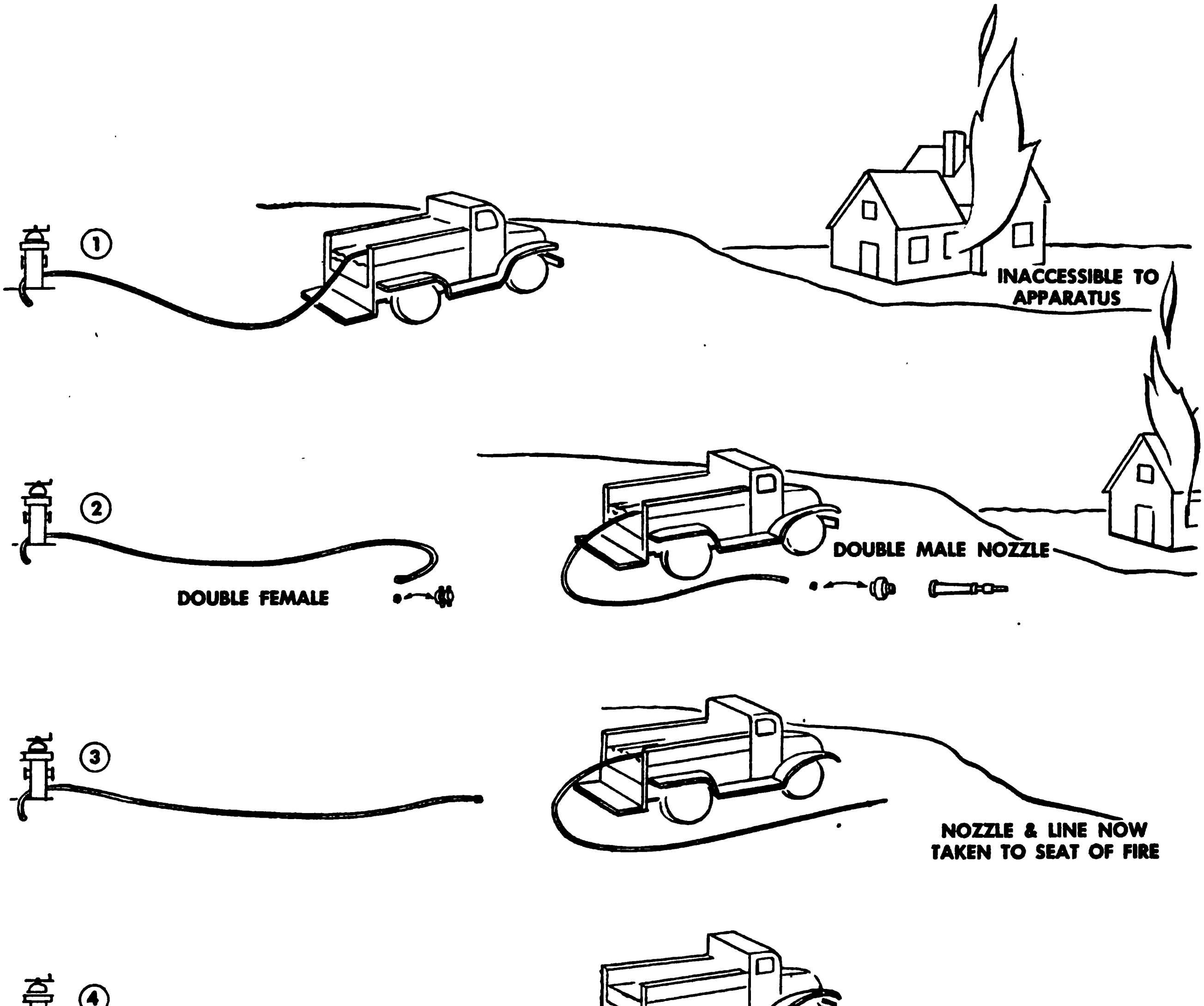


Figure 47. Skid-load finish for reverse lay. Makes about 125 feet of hose immediately available at fire.



① *Hydrant supply line is laid after booster line is placed in operation.*
② *Operator removes hose from body and breaks coupling.*
③ *Hose from hydrant is connected to pump intake and water is turned on, giving booster continuous supply.*
④ *Line is stretched from pump toward fire.*
⑤ *Line is broken and nozzle attached.*

Figure 48. Straight lay backing up a booster line.



① *Truck starts straight lay driving as close to fire as practical.*
② *Hose coupling is broken and male and female couplings attached as indicated.*
③ *Hose is advanced to fire.*
④ *Truck returns to hydrant where pump is placed in service.*
Figure 49. Straight-to-reverse lay to avoid unloading hose in pile behind truck.

Figure 50. Coupling hose. Male end of hose is in left hand. Hose is supported on hip with right elbow to relieve strain at couplings and free both hands to align and tighten threads.

ing couplings. The nozzle man stands facing the male part of the coupling with hose across his right knee. Holding the male part of the coupling with his left hand, he unscrews the loose flange with his right. If he cannot break the coupling, he may set his foot on the male end, freeing both hands to apply force to the turn.

e. Attaching Nozzle. The nozzle can be attached by the same procedure as for breaking the line or as shown in figure 51. On pavement or dry ground, stepping with one foot directly behind the male coupling is usually enough to force the male coupling up so the nozzle can be attached easily. Holding the coupling between the feet is sometimes necessary.

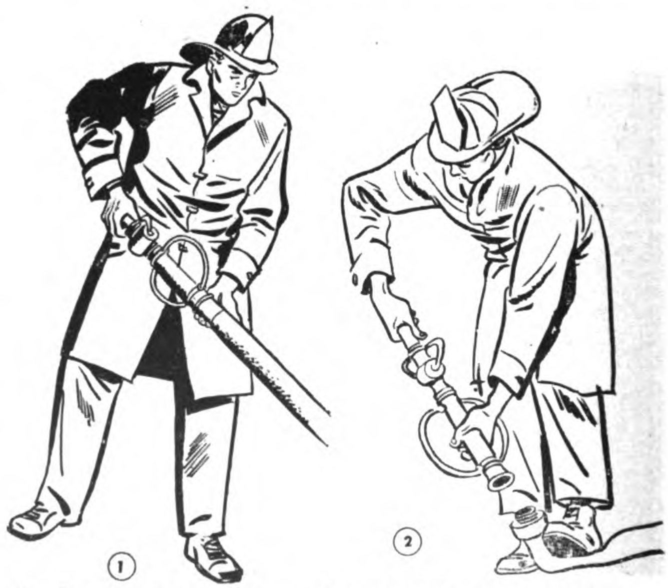
25. Hose Carries

For efficient line advancement, the method of hose carries must be uniform throughout the department. Once the specific operations of maneuvering hose are mastered, they must be applied in cooperation with other workers. Mistakes of one fire fighter throw the crew off balance and waste valuable time. The procedures given below provide harmony and teamwork.

a. Carrying Practices. Figure 52 shows a good method of carrying the nozzle end of the hose when advancing; it leaves both hands free for opening doors, climbing ladders, and so on. The nozzle is out of the way and its weight holds the hose to the shoulder. The hose can be carried on the shoulder next to the line for a short distance. Figure 53 shows methods of carrying the hose back of the nozzle man. For the shoulder carry, care should be taken to place hose on the same shoulder as the nozzle man. The underarm carry is particularly good for advancing lines at street level. This underarm load can be picked up easily from the skid-load finish.

b. Advancing 2½-inch Hose from Straight Lay. Figure 54 shows the method of advancing the straight lay from hydrant to fire. Practice and teamwork determine the number of men best adapted to a local condition. As shown, the hose is removed from the apparatus in a prescribed way, enabling nozzle man and fire fighters to carry the hose in an orderly manner. A hose clamp is in place on the line leading in. When the line has been advanced, the hose clamp is removed to charge the line.

c. Advancing 2½-inch Hose from a Reverse Lay. Figure 55 shows the method of advancing the reverse lay of 2½-inch hose from fire to hydrant. This is similar to the straight lay except that good policy requires one man to hold the hose for a time so it feeds out of the apparatus without pulling all hose away from the fire. If possible, a man should be left on the tailboard to make the hydrant connection or help the driver make the engine hook-up. The reverse lay requires *perfect cooperation* between driver and fire fighter. The driver must



① *Left hand is placed on thigh. Nozzle rests on thigh to permit easy alignment for starting threads.*
② *Holding male end with feet to facilitate attachment.*
Figure 51. Attaching nozzle. Nozzle must be in shut-off position when not in operation.

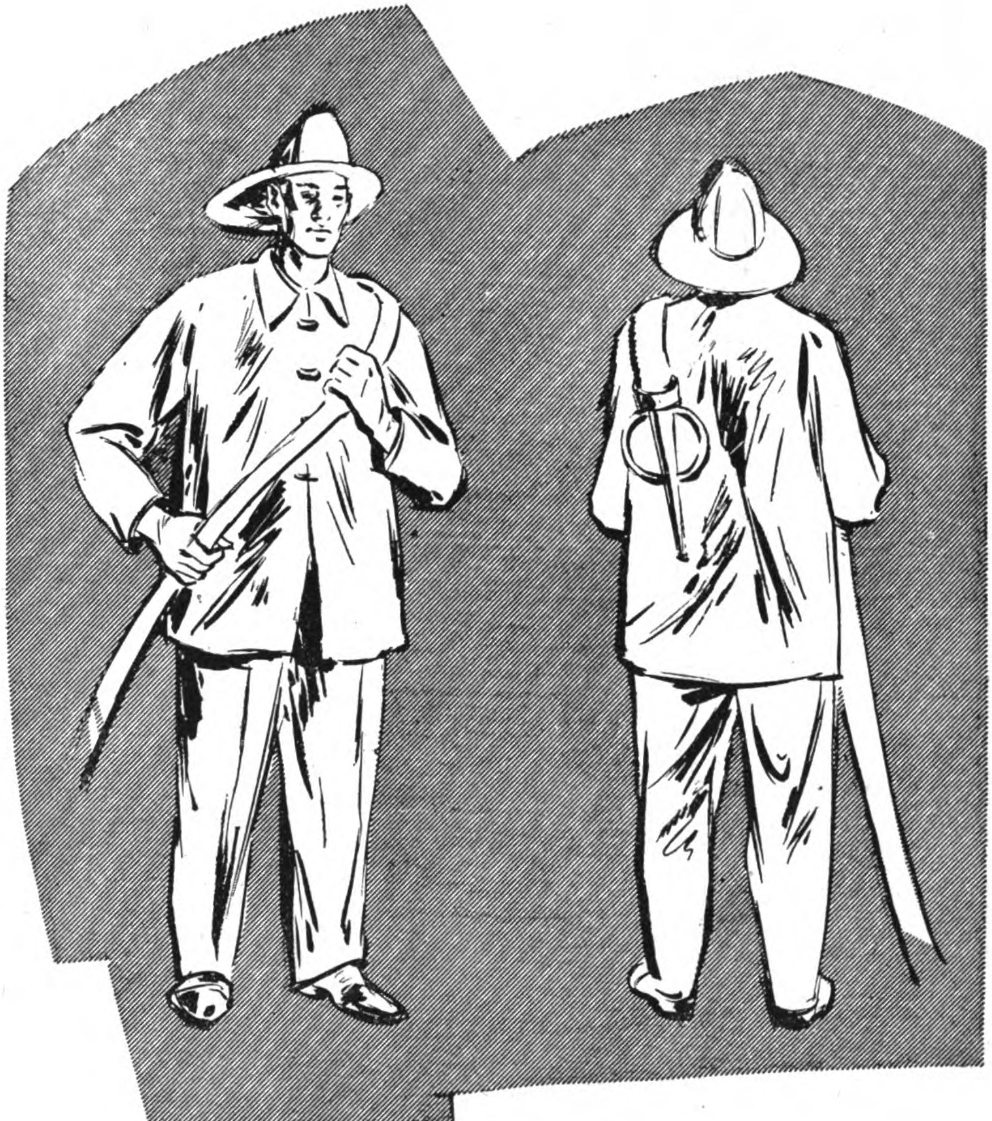
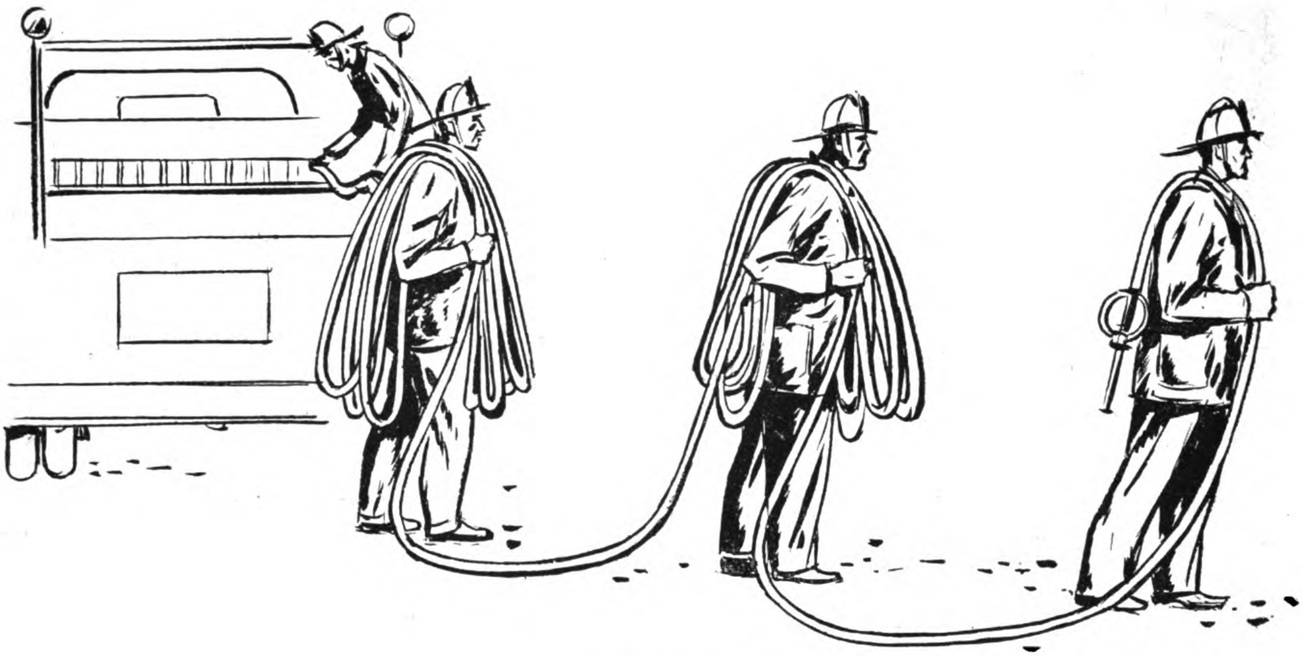


Figure 52. Carrying nozzle when advancing. Hose carried in cross-chest position.



SHOULDER CARRY

UNDER-ARM CARRY

Figure 53. Methods of carrying hose behind nozzle man.

give enough time for hose to be unloaded; fire fighters must give the driver the proper signal.

d. Removing 2½-inch Hose from Apparatus by Hand. Having enough hose at the fire for advancement is a problem whether a straight or reverse lay is used. Dumping hose off the apparatus into a pile directly behind the truck invariably results in tangled hose. Hose can be removed more easily from almost any load previously described, preferably the horseshoe load, by the method shown in figure 56. The operator grasps two handfuls of the looped ends of hose and steps backward, allowing hose to feed out on the ground in straight parallel lines *at least 15 feet* from the apparatus tailboard. This pulls out about 60 feet of hose from the horseshoe load. If more hose is desired at the fire, another pull is taken directly alongside the first. In case of a straight lay, the hose clamp should be applied before the extra hose is unloaded.

e. Advancing 2½-inch Hose up a Ladder. Advancing 2½-inch hose up a ladder should always be done with a dry line if possible. If the line is already charged, time and effort are saved if the line is drained before advancing it. Figure 57 shows the method of advancing a dry line up a ladder. Men climb about 10 feet apart with about 20 to 25 feet of hose between them. Additional hose must be fed to the men on the ladder so they will

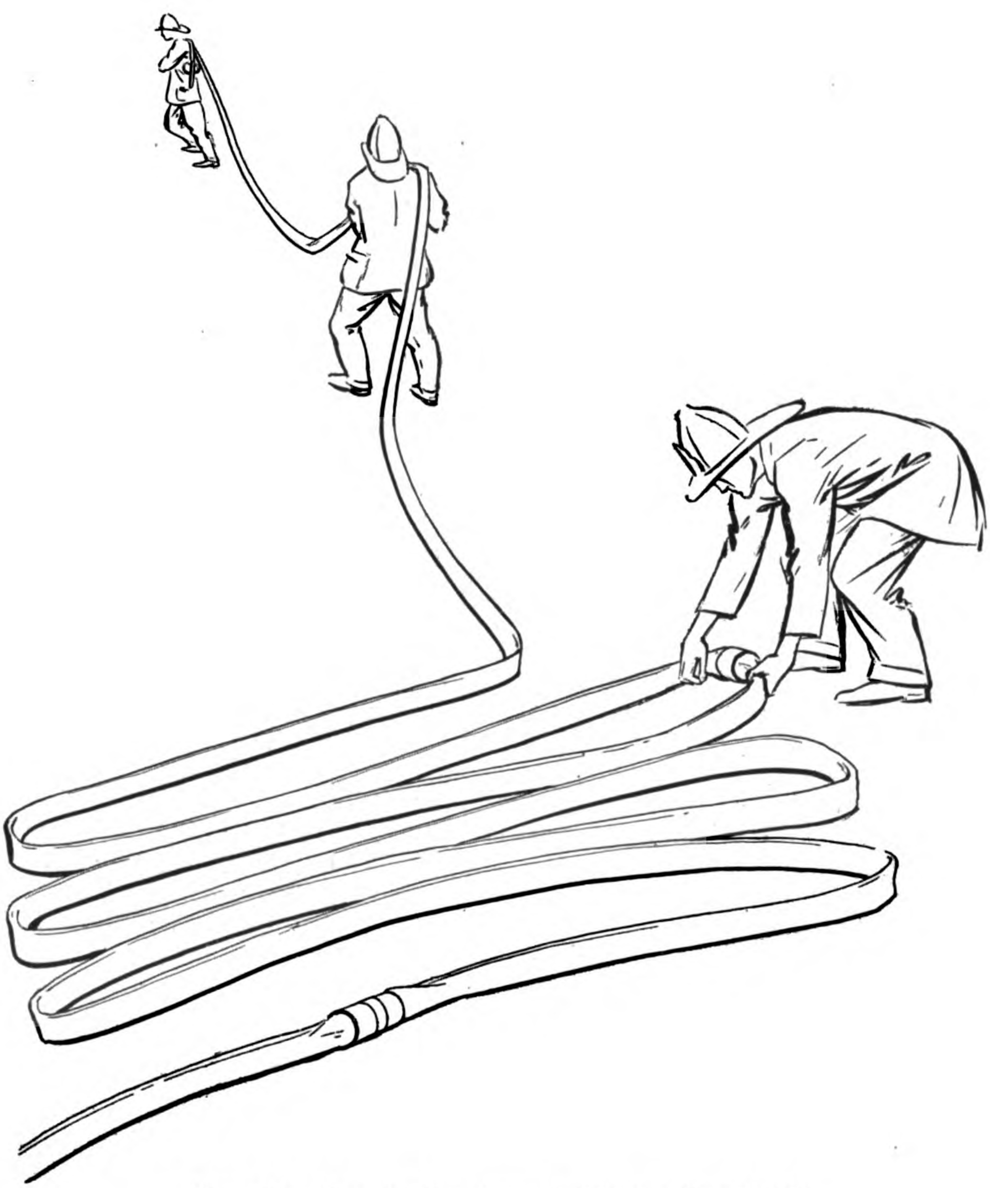


Figure 54. Advancing hose from straight lay. Hose is laid out behind truck, each man picking up hose at coupling.

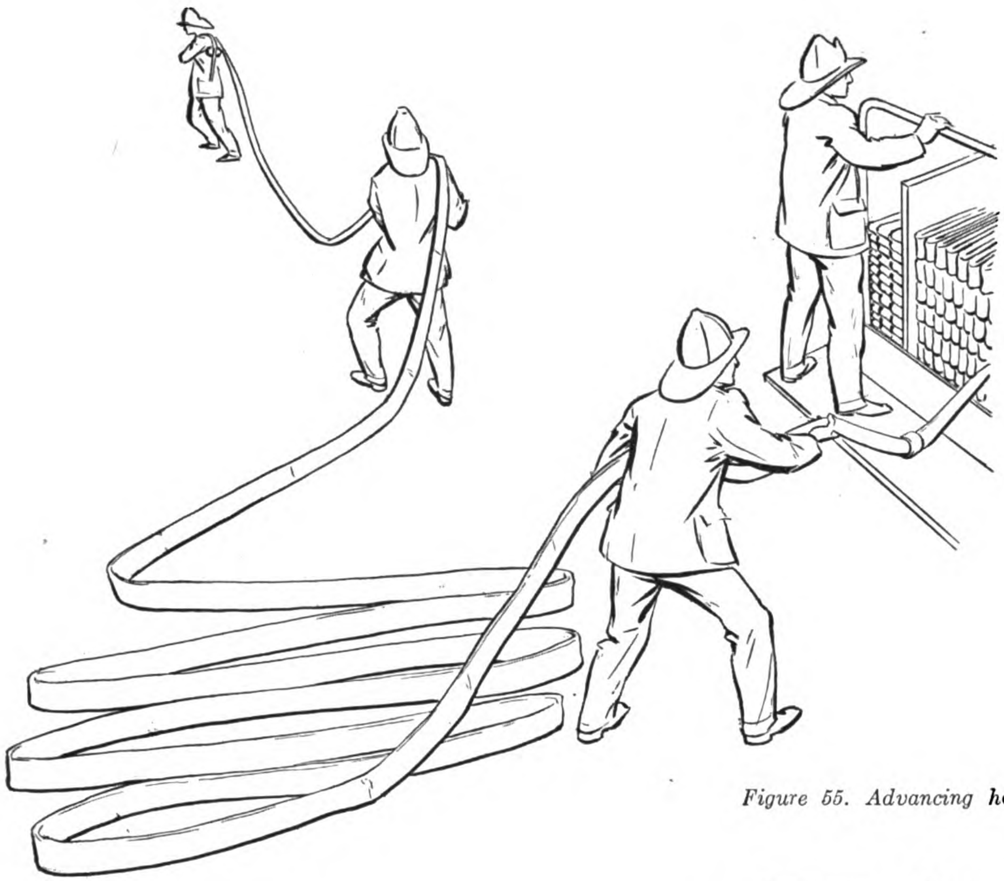


Figure 55. Advancing hose from reverse lay.

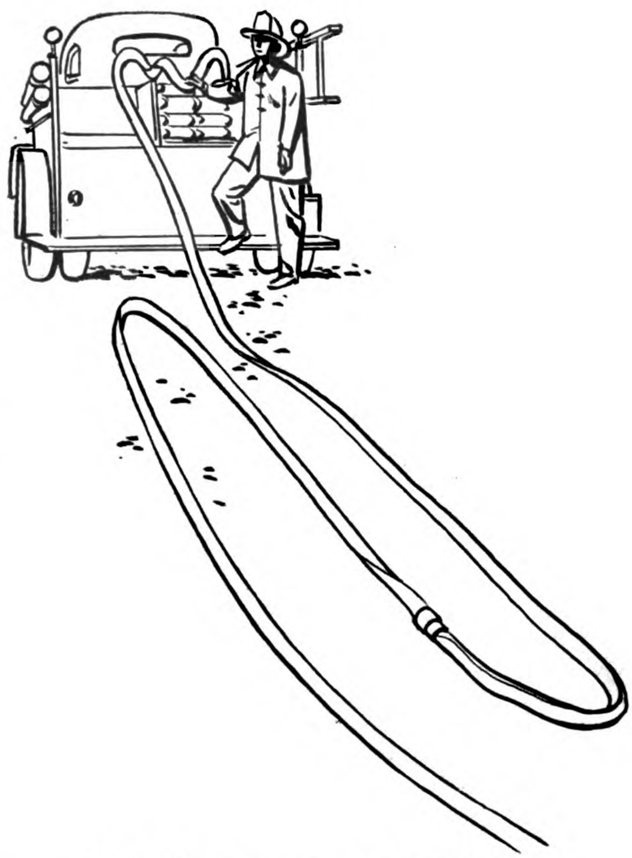


Figure 56. Removing hose from apparatus.

not become fouled. When enough hose for adequate maneuvering has reached the desired floor or the roof, the line should be anchored to a fire wall or a window sill with a rope hose tool, chain, or strap. The anchor should be made directly below the coupling to remove the strain.

f. ADVANCING 2½- OR 1½-INCH HOSE UP A STAIRWAY. Hose is hard to drag in an open place and exceedingly difficult around obstructions offered by a stairway; much time can be saved if the hose is carried. Figure 58 shows a method of advancing up a stairway with the underarm carry. If hose has been properly removed from the apparatus, the fire fighter can easily get an armful as it lies on the ground. Advancing is faster and much easier if the line is kept dry until the fire is reached; this can be done by keeping the hose clamp in place until the proper time for release.

g. HOISTING HOSE WITH HAND LINE (fig. 59). It is sometimes necessary to take a hose line to an upper window or over a roof parapet with a hand line. The line should be dropped from the desired point and secured to the hose. The nozzle should be turned back on the hose to prevent injury. To

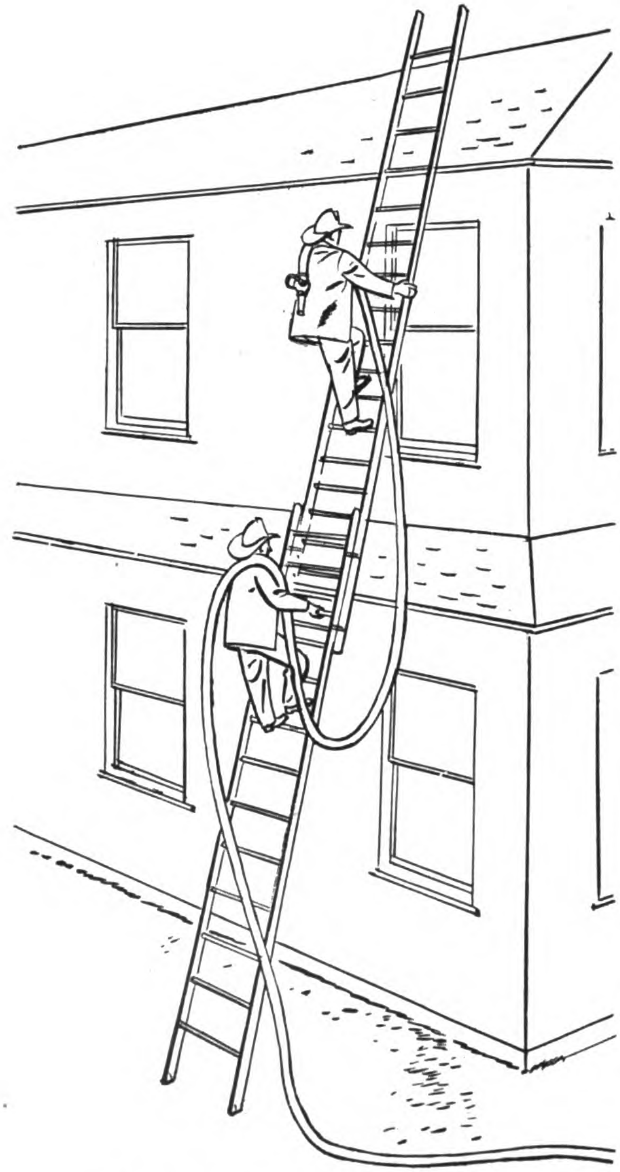


Figure 57. Advancing line up a ladder.

lower a line, the tie should be made as shown. For ease in hoisting, the line should not be charged.

h. Replacing Burst Sections or Extending Short Lines. Either replacing a burst section of hose or extending a short line requires shutting down the line. A hose clamp and one or more sections of hose are required. The required amount of hose should be laid in place before applying the hose clamp so connections can be made quickly. If a hose clamp is not available, the line may be kinked behind the coupling to save time required to go back to the hydrant. (See fig. 60.)

i. Lengthening Line. Every precaution must be taken to provide enough hose for possible maneuvering needed at a fire to reach any part of involved structures. When 1½-inch lines are fed by a 2½-inch line, the larger line must be long enough to be advanced as needed. When a line must be lengthened, the method illustrated in figure 61 is excellent.

j. Handling Hose on Ladder. Working on a ladder is rather unstable, especially when handling a charged hose. To prevent accidents and save effort, the hose can be anchored to the ladder as shown in figure 62. A hose rope, hose strap, or hose chain may be used for this purpose. Figure 63 shows how the rope hose tool may be used.

k. Special Procedures. Several methods for laying lines and handling hose, not specifically described above, are illustrated in figures 64, 65, 66, 67, and 68.

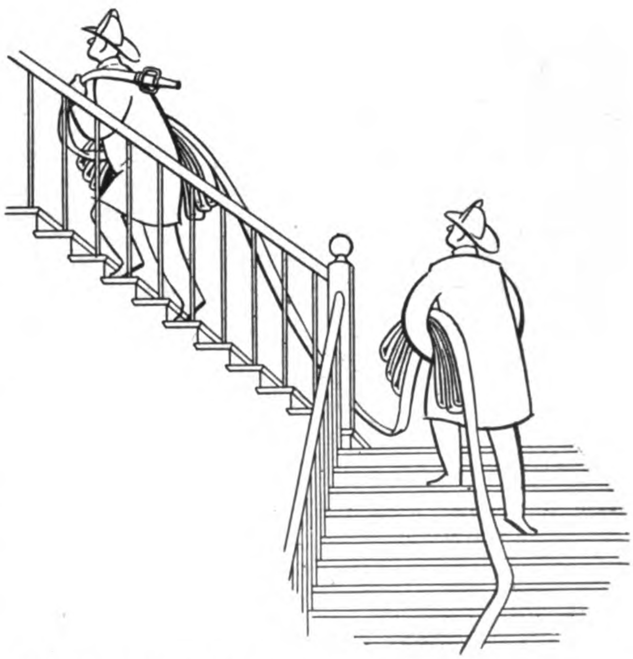


Figure 58. Advancing line up a stairway. Easily done from a skid-load finish.

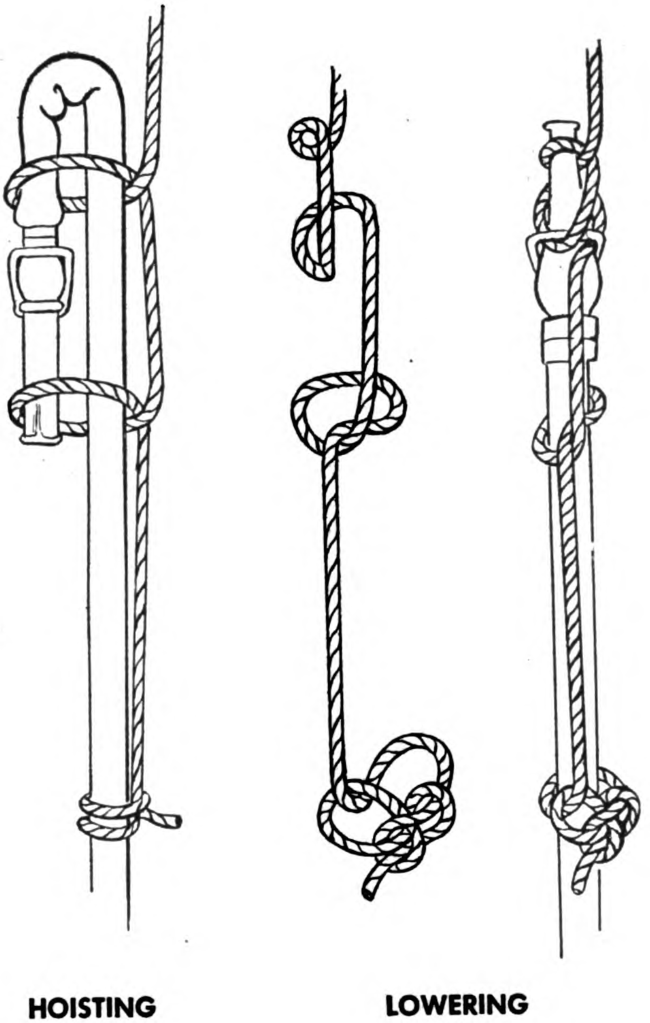


Figure 59. Ties for hoisting and lowering hose.

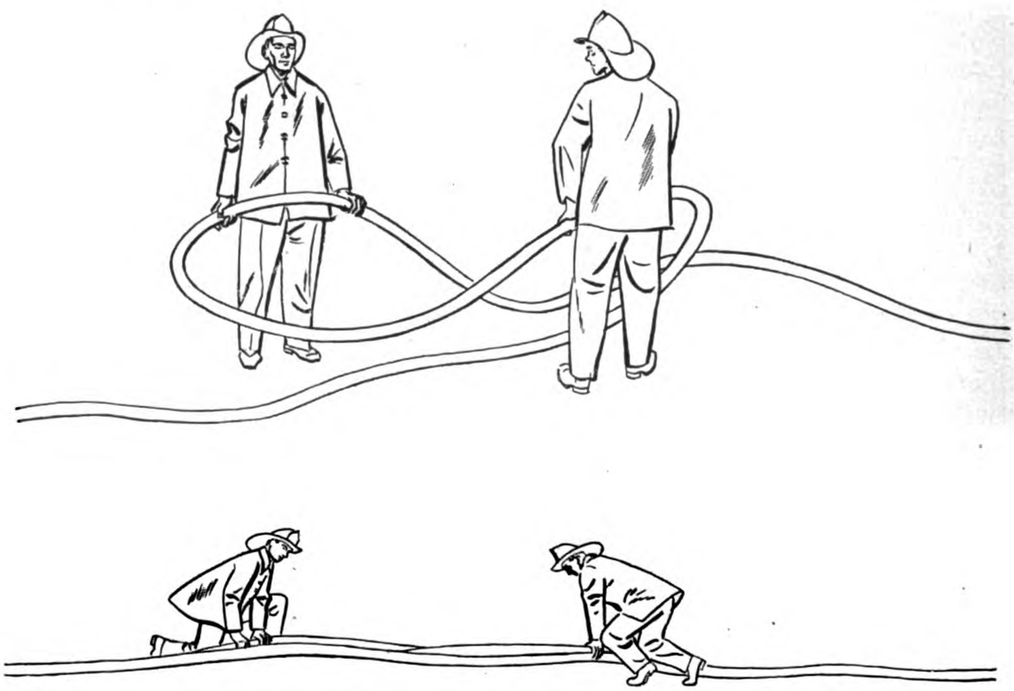
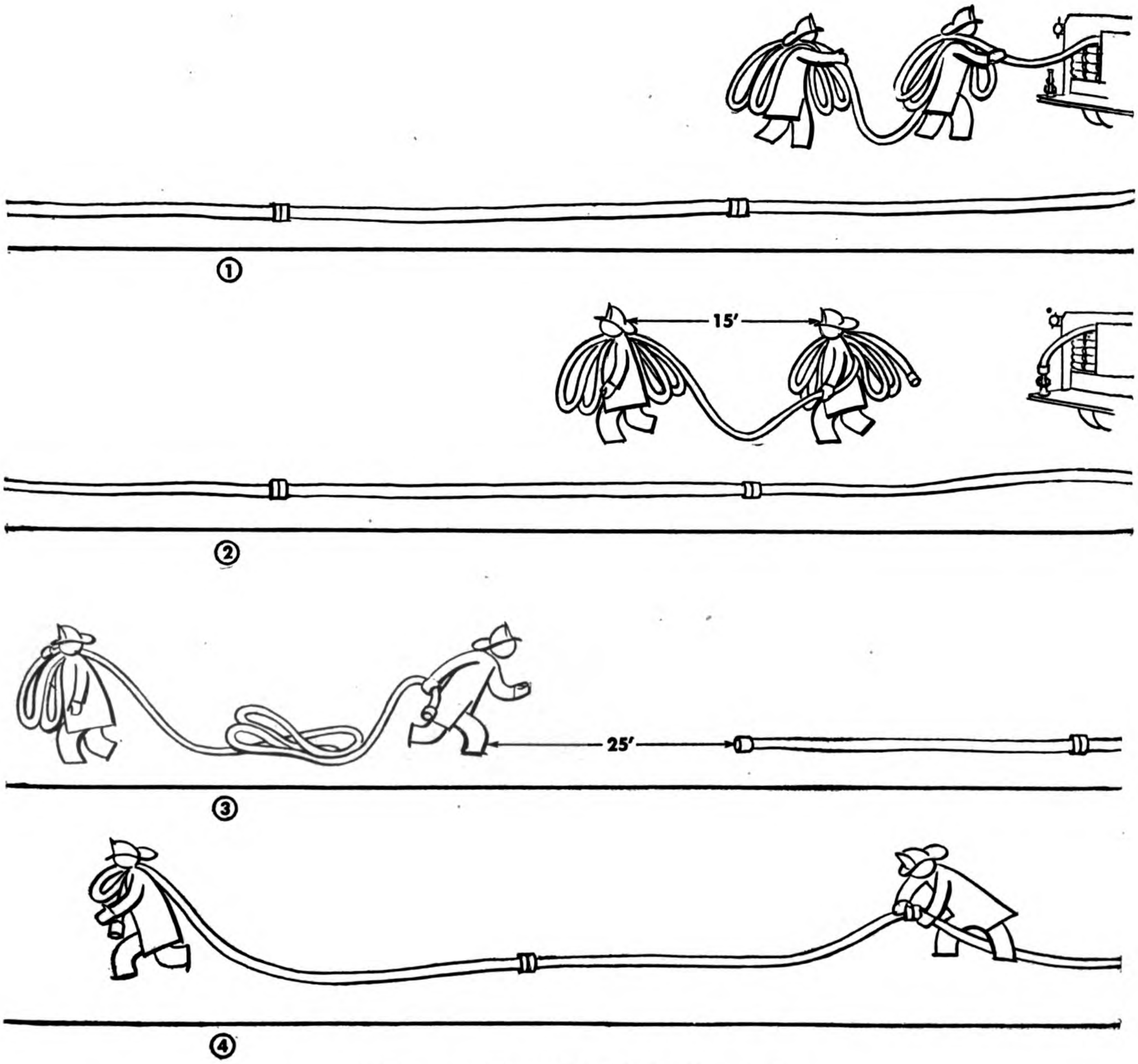


Figure 60. Kinking a charged line to stop flow of water.



① *Two men taking 100 feet of hose from truck.*
② *Proceeding to end of line.*
③ *When second man is 25 feet beyond end of line to be lengthened, he drops hose and goes back to make connection.*
④ *Line is connected while first man continues on, paying off hose from shoulder.*
Figure 61. Lengthening a line of hose.

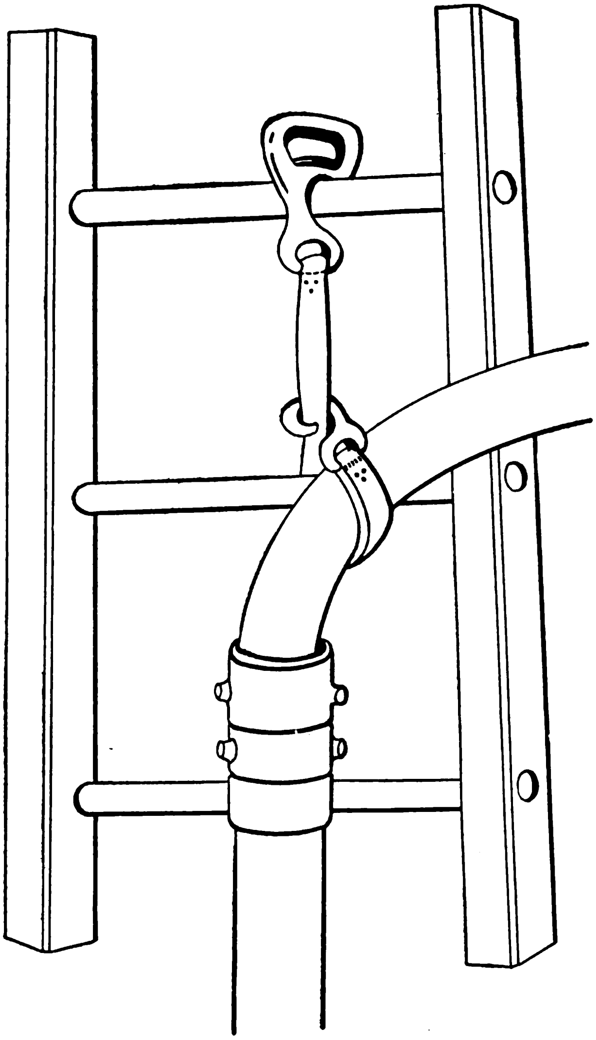


Figure 62. Ladder strap used to secure hose to ladder. Opening in strap must be in direction of pull so strap cannot slip out.

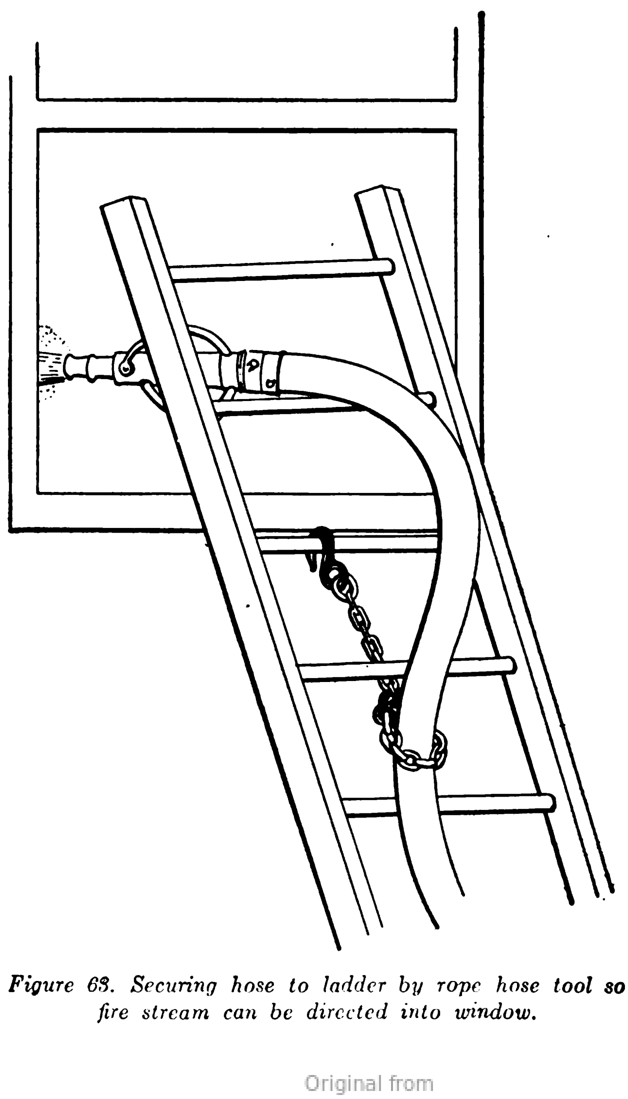


Figure 63. Securing hose to ladder by rope hose tool so fire stream can be directed into window.

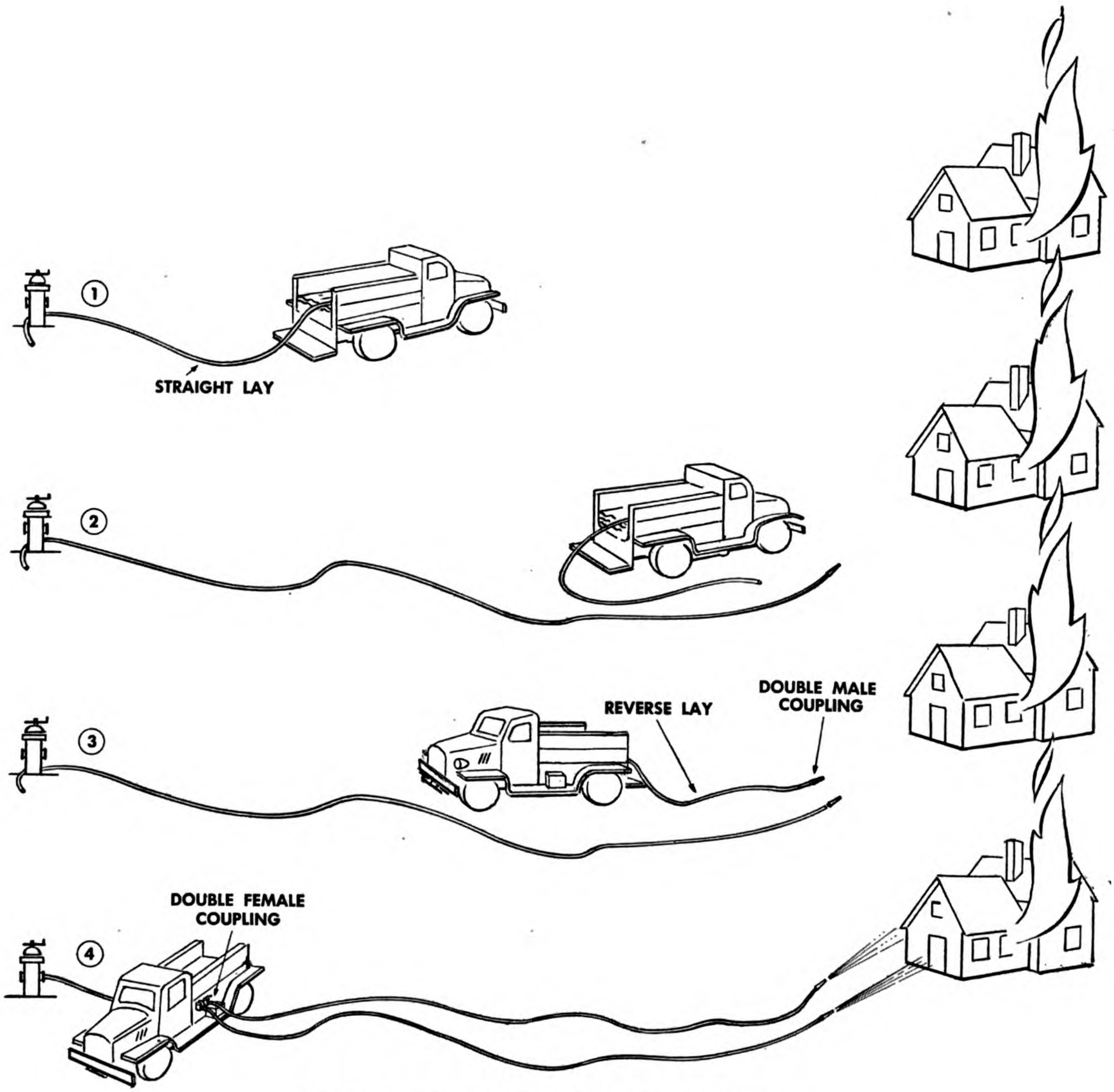


Figure 64. Laying two lines of hose from a single truck.

Figure 65. Forming shoulder loads for moving hose line.

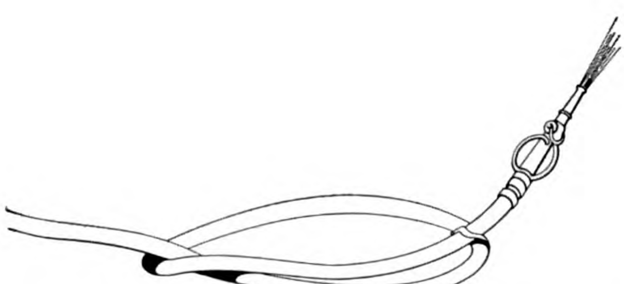


Figure 66. Tying hose to counteract reaction or kick-back.

Figure 67. Carrying a properly folded single section of 2½-inch hose.

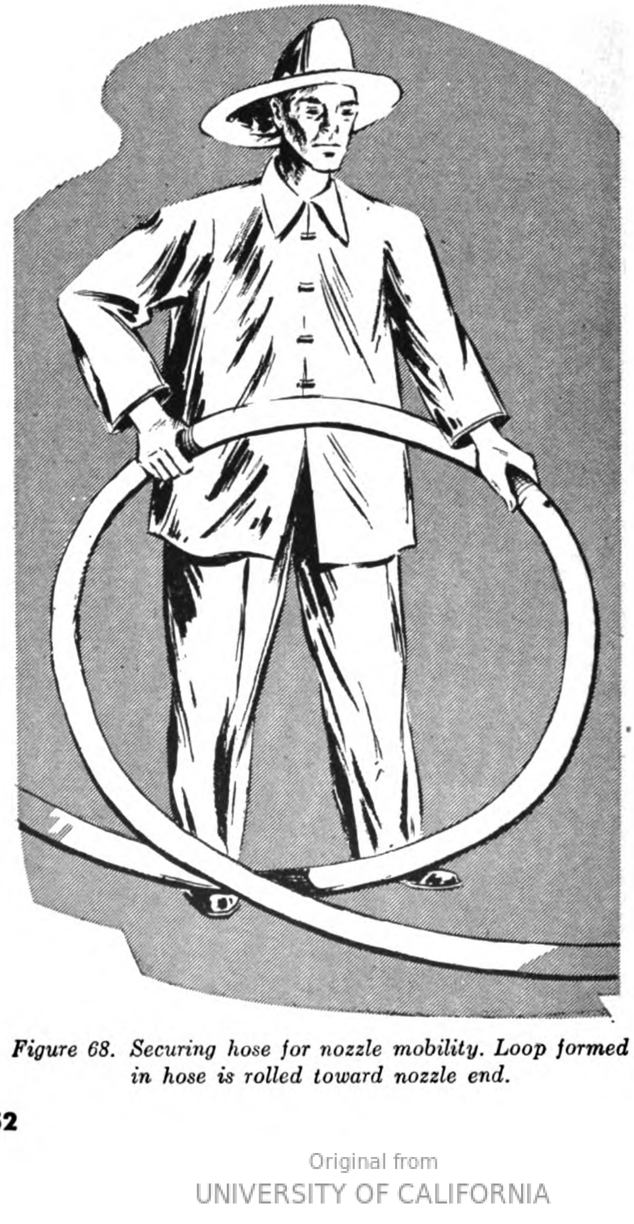


Figure 68. Securing hose for nozzle mobility. Loop formed in hose is rolled toward nozzle end.

SECTION VIII

SALVAGE

26. General

Salvage work in fire fighting consists of preventing excessive damage by fire, smoke, and water. The practices below have proved effective in the light of proper-loss reports from War Department records and actuarial records of other groups. Keeping fire loss at the minimum requires knowledge of salvage operations and ability to improvise new methods. Salvage of property that has been exposed to fire requires a knowledge of materials and equipment; the extent to which they are affected by fire, smoke, and water; and precautions to be taken against further damage. The amount of work done at a fire depends on salvage equipment available and the extent and nature of the fire. The officer in charge of a fire must prevent unnecessary damage to the contents of the building. Fire department personnel should look for conditions which prevent efficient salvage operations at fires and recommend necessary corrections on their tours of inspection. Improper construction may cause large water losses. Shelves built to the ceiling directly against a wall make salvage impossible unless contents are removed, because water flows down the wall wetting the contents. One common obstacle to efficient salvage is material piled on the floor without skids. The lower portion of such piles are difficult to salvage when large amounts of water are used. Material stored in paper boxes or cartons frequently spills when the bottom of the containers is wet, thus ruining the entire contents in spite of perfect covering of boxes and dyking with sawdust.

27. Procedure

The following procedures protect the contents of structures from fire, smoke, and water damage.

a. Material on lower floors can be covered. If not too heavy, they can be moved outside or to another part of the building.

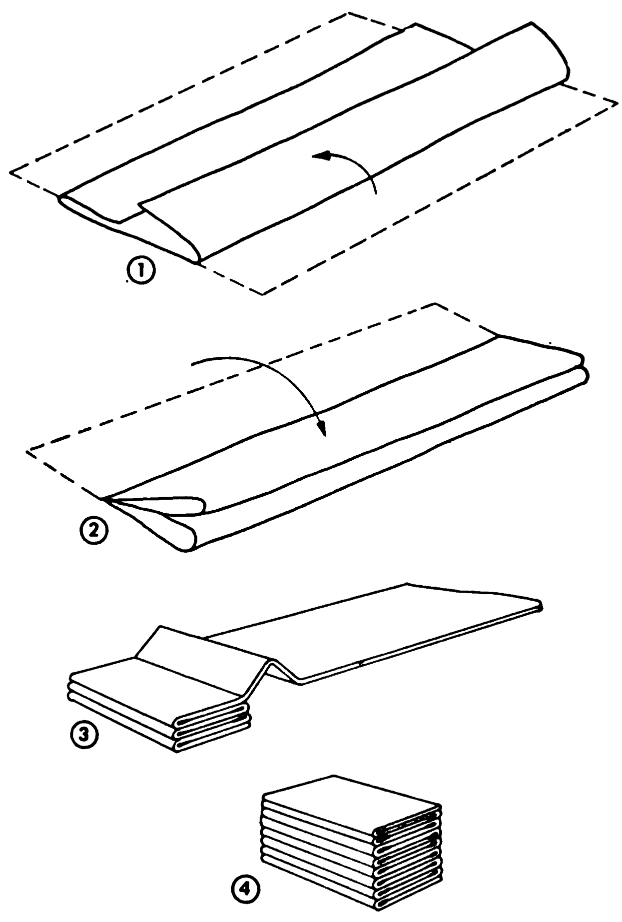
b. Heavy crates, packing cases, machinery, and the like should be covered. If metal materials get wet, wiping the metal dry and oiling it prevents rust.

c. Water often causes as much damage as the fire itself. Proper application of water at the seat of a fire prevents much water damage. Fire fighters should watch for leaky hose and connections and water spraying on dry material. When the fire has been extinguished, all floors should be cleared of water by sweeping it toward a door or opening.

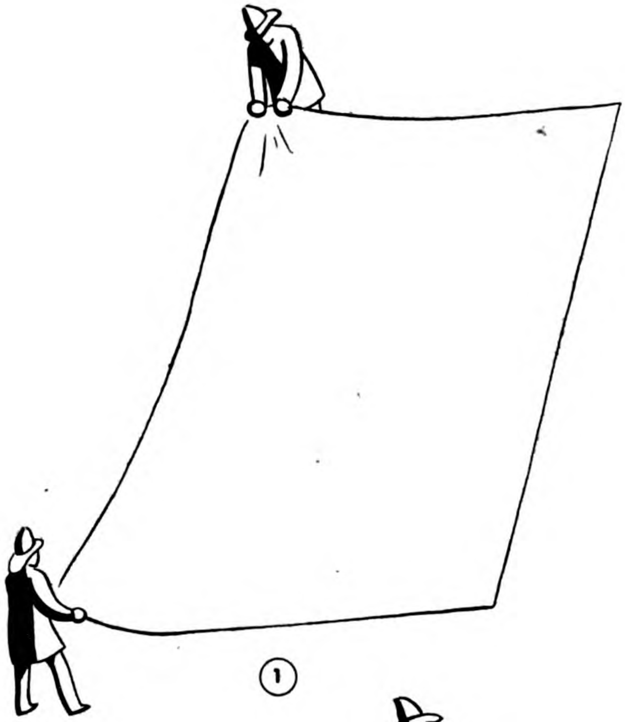
d. Chopping holes promiscuously must be avoided because it frequently increases the damage.

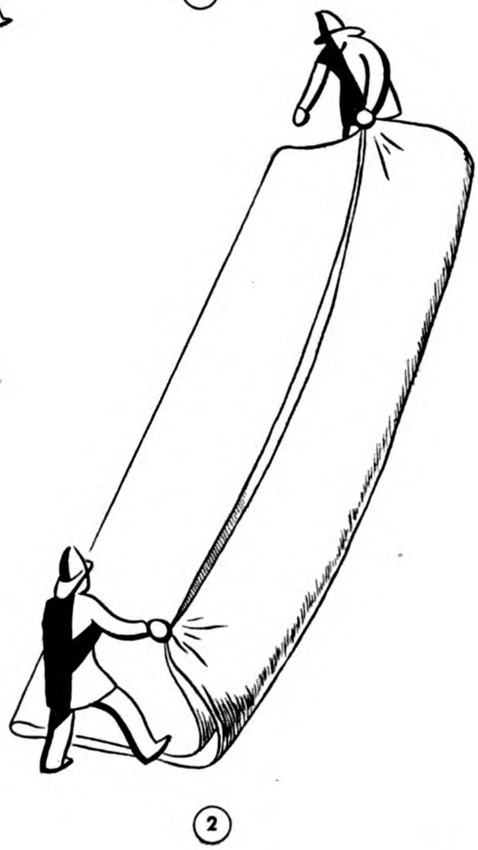
e. Foodstuffs must be protected against becoming tainted by exposure to smoke and water. Bacon, meat, solid fats, and cheese may have little or no salvage value if subjected to smoke or heat.

f. When a roof has been damaged, the hole may be covered with tarpaulin or roofing paper. Care should be taken to remove all nails and sharp objects to prevent damage to covers. When the entire roof is destroyed, temporary roofs of canvas truck covers may be installed. Covers must be securely fastened to prevent their coming loose.



① Fold ends of cover to center.
② Fold cover double.
③ Make 10-inch folds.
④ Continue folding until complete.
Figure 69. Accordion fold.





g. Further damage by water can be prevented by using sawdust to absorb water and forming dykes, directing water outside through doorways or other openings. Floors can be drained by drilling holes in them.

h. When absorbent materials are involved, care is necessary to prevent the excess weight added by water from collapsing the floor. Fire fighters should be trained to make a speedy estimate of the weight of water being used by calculating from known nozzle size, water pressure, and time.

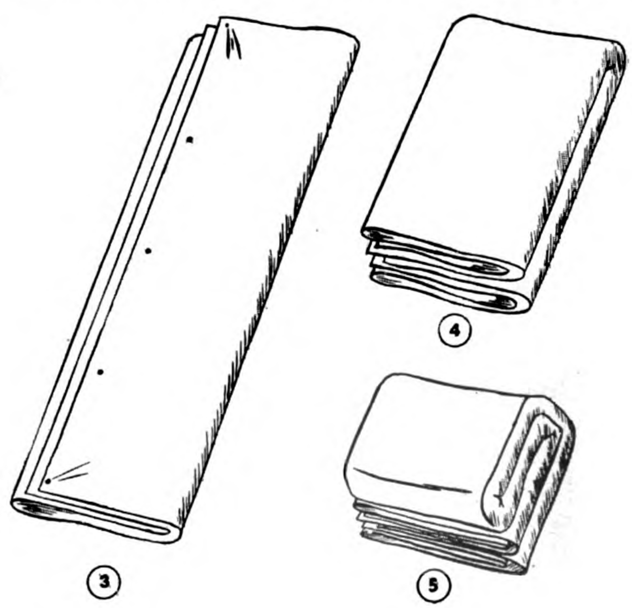
Example: A $1\frac{1}{8}$-inch nozzle at about 40-pound pressure delivers about 237 gallons per minute. Water weighs about 8 pounds per gallon. Therefore, 8×237, 1896 pounds or almost 1 ton of water, is delivered every minute.

i. Articles of special value should be removed from the debris as soon as fire has been extinguished; debris would be removed from the building, floors swept, and excess water removed with brooms and squeegees. Sawdust should be sprinkled over floors to absorb the remaining water and then removed with shovels or push brooms.

j. Office records of administration buildings, headquarters, and the like should be fully protected with canvas covers.

28. Salvage Covers and Uses

Common sizes of canvas covers used for salvage are



① *Positions for starting fold.*
② *Fold cover to center.*
③ *Fold to center again.*
④ *Bring ends together.*
⑤ *Fold again lengthwise.*

Figure 70. Fold for large salvage covers.

12 by 18 feet weighing approximately 38 pounds and 14 by 18 feet, approximately 50 pounds. Methods of handling these covers are discussed below.

a. Accordion Fold. To permit convenient handling and easy manipulation, 12x18 covers are folded as shown in figure 69.

b. Large Cover. Because of its size and weight, the large cover is folded as shown in figure 70. It is carried on the shoulder with the corners in front and toward the body. (See fig. 71.) To unload the cover from the shoulder—

(1) Grasp ropes at corners nearest body; other man grasps remaining ropes.

(2) Drop cover to ground and stretch cover out near material to be covered.

(3) Both men drop inside edge of cover, holding outside corners tight.

(4) Raise cover quickly, carrying it over object, allowing air to balloon cover.

(5) Tuck in all edges and corners at bottom.

c. One-Man Throw (fig. 72). The one-man throw is a quick method of spreading a 12x18 cover. It can be used to cover desks, office records, shop machinery, and the like.

(1) Place center of folded cover over either forearm; grasp bottom fold with the fingers; reach in next to body with other hand and grasp three folds between thumb and fingers, thumb down.

(2) Swing arm up and over the shoulder; flip the three folds over back of hand to give weight to the throw.

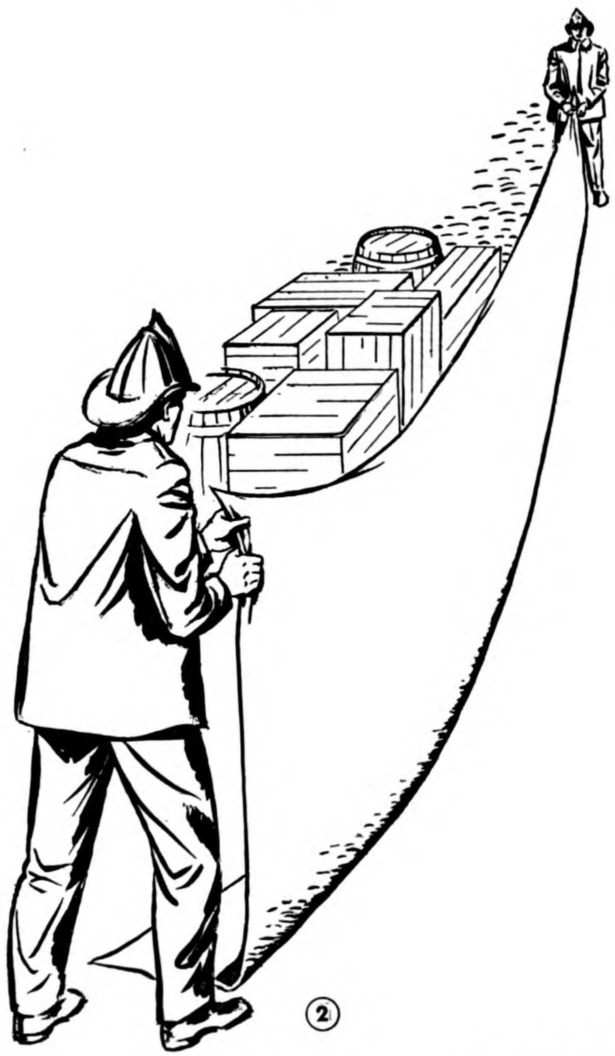


Figure 71. Spreading large cover.

Figure 72. One-arm throw.

(3) Bring hand forward and keep arm stiff; throw cover with a straightarm throw over the object to be covered.

(4) Open cover and tuck in edges at bottom.

d. Counter Pay-Off (fig. 73). The counter pay-offi is used when material must be covered with care.

(1) Place cover over forearm with bottom fold held with fingers.

(2) Have a second man grasp top fold and walk backward, both men raising cover as it unfolds.

(3) Place cover gently over material.

(4) When cover has been draped, tuck in edges at bottom.

e. Catch Basin. Contents and interiors of buildings may be damaged by water dripping through a floor or ceiling in which a drain cannot be made. To prevent this, improvised basins (fig. 74 ①) are sometimes needed to catch the water, which can be removed later by bailing.

(1) Construct catch basin by placing furniture, boxes, or other material in a circle or square.

(2) Form basin with cover.

(3) Fasten cover at sides with bottom of basin resting on the floor.

(4) To make shallow catch basins, roll edges of cover.

f. Window Drain Chute. *S*-hooks, cord, and pike poles can be used as in figure 74 ② to build a chute which directs water through windows, thus protecting contents and interiors of buildings from water damage. Light rope or heavy cord can be tied through the grommets to support the covers.

Note: *S*-hooks can be improvised from heavy wire, welding rods, or 3⁄16-inch cold-rolled steel rods. Cut rods about 8 inches long, sharpen ends on grinding wheel, and bend to *S*-shape.

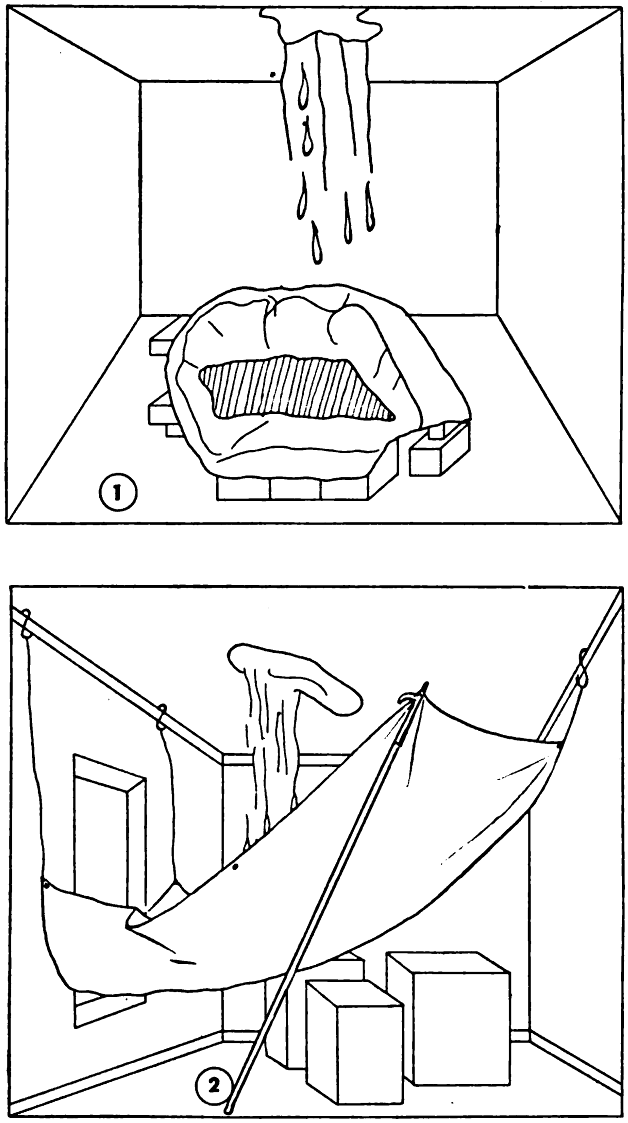
g. Shelf Protection. To protect material stored on shelves, cover shelf with one or more canvas covers. Use *S*-hooks, nails, and cord to suspend cover from walls and ceiling or secure cover by weights. When more than one cover is used, make laps of about 1 foot to prevent leakage.

h. Stairway Drains. To protect the interior structures and contents from water damage, stair-

Figure 73. Covering a counter.

way drains of canvas covers are sometimes needed to direct water from upper floors to the outside. Two methods of forming stairway drains are illustrated. Figure 75 ① shows the method used for a stairway with open or closed sides when protection of walls is necessary. Figure 75 ② shows an alternate method. Two men and two canvas covers are required to perform the operations efficiently. The first cover is spread by the one-man throw at the bottom of the stairs and fitted to the steps. The second cover is placed at the top in the same manner, overlapping the first about 1 foot.

i. Tools and Equipment. Tools most commonly used in salvage work are squeegees, brooms, shovels, buckets, and sawdust. Shovels and buckets are used first to remove debris. Water is removed from floors with squeegees and brooms. When most of the water has been swept out, sawdust should be sprinkled over floor to absorb remaining dampness. Sawdust may be used to make dykes, to form drains, and catch small drips; it can be carried in sacks placed in fire apparatus.



① *Supported by furniture and boxes.*
② *Window drain chute.*
Figure 74. Catch basins.

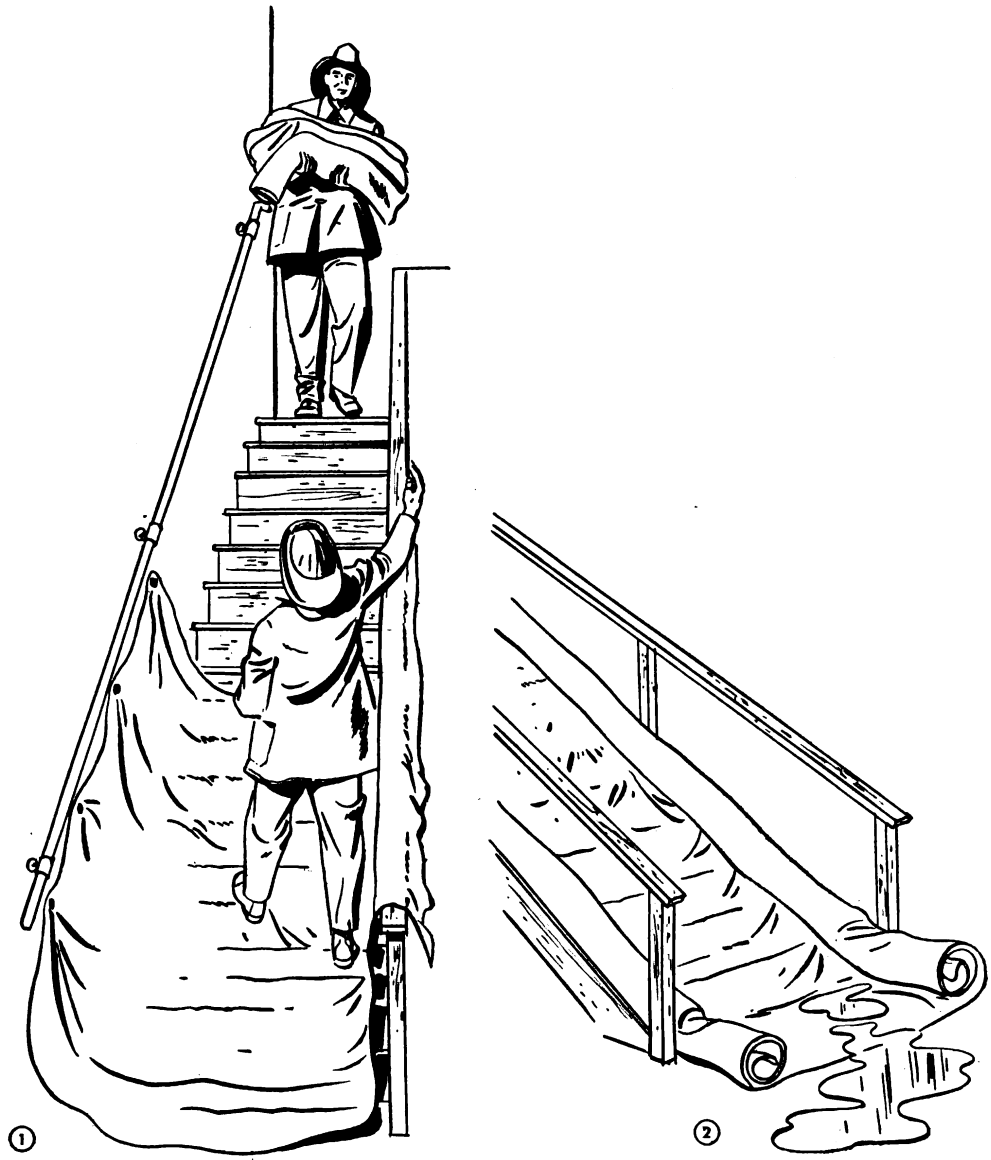


Figure 75. Stairway drains.

SECTION IX

FIRE STREAMS

29. General

Water is the most practical extinguishing agent for ordinary fires. It absorbs heat rapidly and has much greater heat-absorbing capacity than most materials used for fire extinguishing. A great amount of heat is required to raise cold water to the boiling point; much more heat is required to change water to steam. Only a small fraction of the theoretical maximum cooling effect can ordinarily be utilized.

a. Point of Application. Water must reach the base of the fire to be effective. A stream or spray played into the flames and smoke does little more than cool the smoke unless it actually reaches and wets the burning material. Enough water must reach the base of fire to absorb heat faster than it is produced by the burning material. For large fires, a substantial stream of water is needed to penetrate the smoke and flame. A good stream under pressure is also necessary to force water into cracks and open spaces in burning material. The most efficient fire stream is large enough to do the job without any excess water to cause unnecessary damage.

b. Solid Streams. The most effective manual method of applying the proper amount of water to control a given fire area is from a hose nozzle. Fire streams project water over a considerable area and extinguish fires that might otherwise be inaccessible. Fire streams must reach from the best point of approach to arrive at the base of the fire in a condition to be most effiective; this fire-stream production is the concern of all from nozzleman to pump operator.

c. Spray. Some fires can be fought better with a spray than with a solid stream. Fine spray does not carry and penetrate, but it utilizes the cooling effect of water more efficiently because of the enormously increased surface of water to absorb heat. As individual drops are heated, steam or vapor is formed to some extent, and a blanketing or smotheding effect is produced which is of value against certain inflammable liquids and other surface fires. The spray from fog or vapor nozzles lack carrying power, and this type of nozzle can be used to advantage only at short range. Fine sprays such as from so-called fog type nozzles, particularly at higher pressures can be most effective when applied in a sweeping motion to cover large areas.

30. Requirements

a. General. The senior officer of a fire company must be able to determine the extinguishment requirements of a fire and know the means available for meeting those requirements.

(1) Since every fire, except those caused by explosions, starts small and develops as more combustible material is involved, extinguishment is easy if fires are reached in the early stage. Fire-stream requirements are small in the early stages, permitting extinguishment with a booster line or portable extinguisher.

(2) If not discovered in the early stage of burning, approaching the base of the fire becomes difficult. The fire stream must then produce not only the amount of water required for extinguishment but also must carry through space to the point of use. Enough volume can be supplied with small streams, but they must have shape and velocity to carry them to the base of the fire.

(3) (*a*) If not discovered or controlled until the whole building is burning, a fire can be extinguished only by using large quantities of water. Even then the fire stream must be controlled to supply the greatest amount of water from a safe distance and yet reach the fire at the point of burning. This stage requires heavy master streams.

(*b*) The fast-burning temporary frame structures on Army posts which have large areas unbroken by partitions cause rapid fire spread. The use of 1½-inch hose streams on most posts depends on sound judgment and experience of the fire officer; 1½-inch hose lines should not be used from pumpers unless enough 2½-inch hose is available for support. The 2½-inch line used to supply 1½-inch hose must be long enough to reach any point of the involved structure or exposures. Large streams from monitor nozzles and deluge sets may be used when equipment and adequate water supply are available

b. Spray Streams. Producing a broken stream at close range requires a special nozzle and high pressure. These nozzles, commonly called spray, vapor, or fog nozzles, produce a finely broken mass of spray that envelops or blankets the fire. Water

is usually furnished to the nozzle at high pressure, but enough volume can be supplied from a comparatively small hose. Spray nozzles are not designed to carry streams through a considerable distance.

c. Solid Streams. (1) *Capacity.* Size of hose and velocity of water passing through it determines fire-stream capacity. A 2½-inch hose has almost three times as much water-carrying capacity as 1½-inch hose. Also, the larger hose has proportionately less friction loss. Stream velocity depends on pressure at the pump. Nozzle pressure, as measured by a pitot gauge inserted in the stream, and size of nozzle tip determine capacity discharge of fire stream. Common nozzle pressure of 50 pounds discharges water as follows:

Nozzle tip (inches)	Gpm
¾	117
1	209
1⅛	265
1¼	326
1½	472

(2) *Reach.* The elevated tank or pump forces water under pressure through the hose line; restricting the water stream into the smaller opening of a nozzle further increases the velocity. Increasing nozzle pressure above a certain point, however, breaks up the stream and decreases its reach. Streams from small nozzles break up more quickly than those from large nozzles. Greater reach is obtained without increasing pump pressure by using a smaller nozzle tip. This reduced flow results in less friction loss in the fire hose so water reaches the nozzle with greater nozzle pressure.

Example: Assuming 100-pounds pressure at the pump, a 300-foot line of hose, and a 1¼-inch nozzle, 292 gallons are discharged at 40-pound nozzle pressure, the remaining 60-pound pressure being lost through friction in the hose. If a 1-inch nozzle tip is used, 229 gallons are discharged at 60-pound pressure because the smaller flow results in only 40 pounds of pressure loss from friction. Since larger nozzles throw a stream farther at a given pressure, increasing pump pressure lengthens the reach of the stream more effectively than using a smaller nozzle tip. The effective reach of solid fire streams may be determined roughly as 1 foot per pound of nozzle pressure at high pressures (over 50 pounds) and one and a half times that amount for low pressures.

(3) *Proper shape.* A solid fire stream should stay within a 15-inch circle at a distance of effective reach, and three-fourths of the stream should come within a 10-inch circle at that distance. (See fig. 76.) Too great nozzle pressure breaks up a fire stream, causing it to fail in this test. Anything hindering smooth passage through the nozzle breaks the stream. A protruding gasket back of the nozzle, a partly closed or rough shut-off valve, scratches in the tip barrel, or battered edge on the tip may break the stream and distort its shape.

d. Obtaining Nozzle Pressure. Friction loss is pressure expended in forcing water through the hose. If 90 pounds of pressure is required at the pump to produce 50 pounds at the nozzle, the friction loss is 40 pounds. Hose length, rate of flow, and nozzle size determine the amount of loss in a hose. Friction loss increases directly as hose length increases, the loss being twice as great in 200 feet as in 100 feet of hose. When the rate of flow increases, however, friction loss increases rapidly. Doubling the rate of flow makes the friction loss approximately four times as great. Friction loss

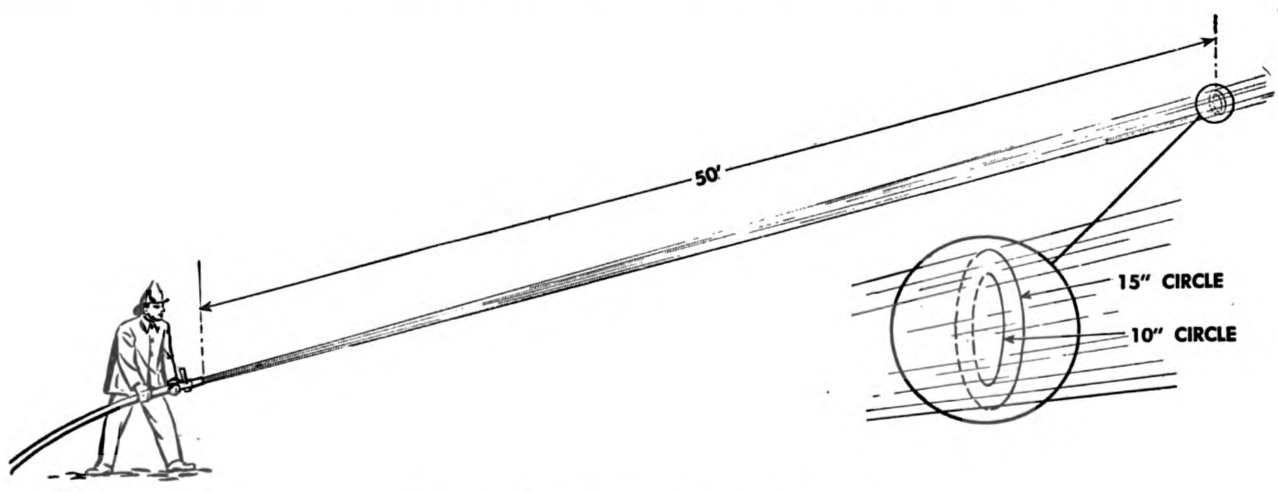


Figure 76. Requirements for solid fire stream.

for various nozzles at 50 pounds of pressure is shown below.

Nozzle size (inches)	Approximate friction loss per 100 feet of 2½-inch hose (pounds)
¾	4
⅞	8
1	10
1⅛	18
1¼	25

Since each fire pumper has hose loaded in layers, the pump operator knows how much hose is out by counting the layers remaining in hose body. In addition, 5 pounds pump pressure is required for each 12 feet of elevation.

Example: In a hose body having no partitions, approximately 200 feet of hose are in a layer. If five layers make the complete load and 2½ layers are left, 500 feet have been laid. If a 1-inch nozzle is being used; friction loss equals 20 pounds per layer. Thus, 2½ layers equals 50 pounds friction loss plus 50 pounds for desired nozzle pressure require an engine pressure of 100 pounds.

e. Practice in Producing Fire Streams. A good practice exercise is making a lay-out from a pumper with a given length of hose and computing the flow of water through the line. Actual pressures at hydrants and nozzle should be read and compared with figures calculated from tables above. This shows how calculations must be made to estimate pressure which must be available at a hydrant or provided by the pumper. Further exercises may include the following:

(1) Lay-outs with nozzle tips of varying sizes and hose lines of varying lengths.

(2) Operating the pumper both from a hydrant and at draft (pond or stream) with various hose lay-outs.

(3) Lay-outs with pumpers in relay to practice problems of long lines of hose.

Note: Each fire pumper supplied by the Corps of Engineers has a plate listing required pump pressure for various nozzle diameters and line lengths. This plate is attached to the pumper as a guide to pump operators.

f. Small Streams. Capacity and reach of small streams is seldom considered as the main objective to produce a workable stream using as little water as possible, thus keeping the water damage to a minimum. Since small hose and tips are employed, it is the practice to raise pump pressure sufficiently to obtain the stream desired. Pump pressures of 80 to 100 pounds is considered sufficient. However, consideration should be given to the height which such lines are taken. Excessive pressure will tend to break up the stream, although in some cases this may be desirable.

SECTION X

VENTILATION

31. General

The problem of ventilation in burning buildings is difficult. Unless fire fighters have a technical knowledge of combustion processes, characteristics of various fuels, oxygen requirements, drafts, effect of heat on air currents and building ventilation, they cannot attack fires in buildings effectively. Ventilation includes removing the smoke, gases, and heat from the building and controlling the fresh air supply to facilitate rescues, protect fire fighters, and prevent spread of fire.

32. Combustion Process

a. FUELS. Carbon and hydrogen are the most common fuel elements in burning material; sulfur and cellulose nitrates, commonly called pyroxylin plastics, are less common. A fuel exposed to flame or spark burns if heated to its ignition temperature in the presence of oxygen. The approximate ignition temperatures of several common materials are listed below:

(1) Dry wood, 500° F.

(2) Paper, 450° F.

(3) Pyroxylin plastics, 275° F.

(4) Cotton cloth, 440° F.

b. OXYGEN SUPPLY. (1) When fuels reach their ignition temperature, they react with oxygen to form new compounds, called the products of combustion. Most of this oxygen comes from the atmosphere, which normally contains 21 percent of oxygen; some oxygen may be supplied by the oxygen content in cellulose materials such as wood, paper, and cloth. Free burning occurs when enough oxygen is present to consume the available fuel. One atom of carbon (C) at its ignition temperature, for example, reacts with two atoms of oxygen (O) to form carbon dioxide (CO_2).

(2) In a closed structure, enough oxyygen is present when the fire starts to support free burning; the hot gases rise to the ceiling, starting a current which forces the cooler air to feed the fire from the floor. If no fresh air can enter the room from the outside, the amount of oxygen is gradually reduced until the fire smolders and smokes. Theoretically, it should finally smother out completely; actually, the smoldering stage is sustained because all the oxygen supply is never exhausted.

(3) When the oxygen content of the air is lowered, the combustion process changes. More and more of the carbon fraction reacts with single atoms of oxygen to form carbon monoxide (CO), which unlike carbon dioxide is toxic and inflammable. Sometimes, fuels will distill because of the extremely high temperatures and join the atmosphere as hot, inflammable gases.

c. PRODUCTS OF COMBUSTION. (1) *Carbon dioxide.* Carbon dioxide, the common product of complete burning of carbon materials, is neither inflammable nor poisonous. As it replaces oxygen in the atmosphere of a closed room, the fire begins to smolder. The danger to personnel in air having high carbon dioxide content is the suffocating effect caused by lack of oxygen.

(2) *Carbon monoxide.* As shown above, carbon monoxide is a product of incomplete combustion. Carbon monoxide gas is more prevalent in unventilated buildings, due to lack of oxygen. An extremely poisonous gas, it produces unconsciousness quickly if the air has a content of 0.5 percent carbon monoxide. Air containing 12.5 to 74 percent carbon monoxide may be explosive. Ignition temperature of carbon monoxide is 1204° F. The toxic quality and inflammability of this gas make it very dangerous.

(3) *Water vapor.* Burning hydrogen combines with oxygen to produce water vapor.

(4) *Sulfur dioxide.* Burning sulfur produces sulfur dioxide, an irritating, suffocating gas that is not inflammable. It irritates the eyes and respiratory passages, and is dangerous to breathe in high concentration.

(5) *Nitrous fumes.* Nitrous fumes include several oxides produced by burning cellulouse nitrates. These fumes are extremely hazardous.

(6) *Densities.* Although the gases of combustion are diffused with the air, they are more highly concentrated at specific levels depending on their densities. The following list of comparative densities indicates the level at which these gases may be found, taking the density of air as a unit.

Air	1.000
Carbon dioxide	1.608
Carbon monoxide	.978
Sulfur dioxide	2.437
Nitrous fumes	1.036 to 1.530

d. SMOKE. Smoke is always produced when com-

bustion is incomplete. Its density, color, and content vary with oxygen supply, intensity of heat, and kind of material being burned. Water vapor and particles of free carbon are generally found in the smoke; such fuels as pine wood may distill, giving off tiny globules of tar. Liquid fuel materials or those that liquefy at high temperatures generally give off dense black smoke. Oils, tar, paint, varnish, molasses, sugar, rubber, and sulfur may burn with such dense smoke that ordinary ventilation practices cannot clear the room.

e. Fuel Gases. Heating combustible materials to extremely high temperatures in the absence of oxygen distills the lighter fuel elements and compounds from the materials into fuel gases. These hot gases need only oxygen and a spark to burn with explosive violence.

f. Progress of a Fire. Figure 77 shows four stages in the progress of a fire in a closed room.

(1) The first drawing shows the fire while it is free burning. Adequate oxygen is still available in the air, and water vapor and carbon dioxide are being produced along with small quantities of carbon monoxide and sulfur dioxide.

(2) At the second stage, the original oxygen proportion of 21 percent in the air is reduced to about 17 percent. Burning has slowed and carbon monoxide production has increased. Room temperature is about 300° F.

(3) Fire is barely visible in the third stage because oxygen has been reduced to 15 percent. Carbon monoxide is produced in increasing amounts, and free carbon and unburned fuel form dense smoke. Intense heat and gases present imperil personnel and constitute an explosion hazard.

(4) In the fourth stage, the fire is smoldering with the oxygen content at 13 percent. The room is completely filled with smoke and gases at a temperature exceeding 1000° F. This intense heat distills some fuels from the combustible materials; the fuel gases mix with other gases present, adding to the fire hazard. Danger to personnel and probability of explosion are extreme.

33. Evaluating Situation

a. General. Careful evaluation of the situation is necessary before an opening is made to ventilate closed buildings. The officer in charge estimates the situation by considering the rescue requirements,

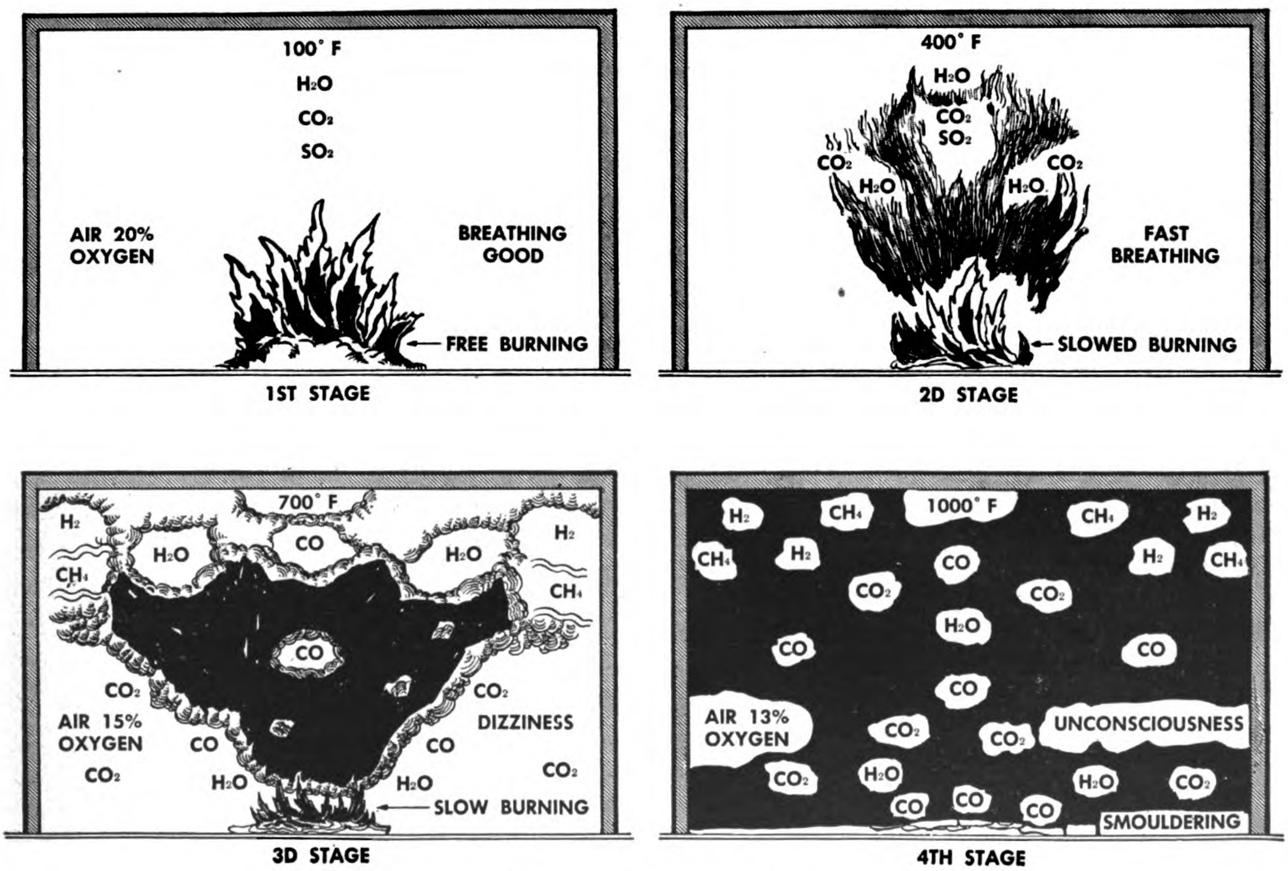


Figure 77. Progress of a fire.

type of building and contents, smoke and heat conditions, and the explosion hazards. He also takes into account weather conditions, manpower and equipment available, adequate safety precautions, and exposed buildings nearby. His evaluation determines the procedures to be taken to accomplish—

(1) Rescues.

(2) Fire protection.

(3) Ventilation.

(4) Fire extinguishment.

b. Type of Structure. (1) *One-story buildings.* One-story buildings with several rooms present more hazards than fires in single-room structures. When hot gases rise to the ceiling, the cooler fresh air from adjoining rooms is drawn under doors or through other openings, permitting the fire to burn longer before it begins to smolder. As the hot gases and smoke fill the entire structure, finding the exact location of the fire becomes difficult and proper ventilation procedure becomes more uncertain.

(2) *Buildings of more than one story.* In buildings with more than one story, hot gases and smoke rise to floors through elevator shafts, stairways, air-conditioning shafts, and similar paths. Reaching the highest possible level, the gases and smoke spread over the entire floor, eventually filling the building from the top down. At the same time oxygen is supplied to the fire from incoming currents of cool air. Smoke is generally seen coming from openings in the upper floors regardless of the location of the fire.

c. Smoke Conditions. Observing smoke conditions may reveal the location, intensity, and size of a fire. When the building becomes smoke-filled, smokes comes out from the roof and upper windows; through openings around skylights, penthouses, and even through cracks in the walls.

(1) Although the pressure inside the building is seldom great enough to force the smoke out rapidly, some indications of conditions in the building can be determined by the speed with which smoke emerges.

(2) Density of smoke can be observed through windows if they are not fogged over.

(3) If the smoke is coming from stories other than the top story, the draft may be effectively blocked from the upper floors.

(4) Smoke coming from one end of the building and not from the other may reveal the location of the fire unless this condition is caused by the wind or draft.

(5) If adjoining buildings have communicating openings, smoke may appear from an adjoining building instead of the one afire.

d. Heat Conditions. An indication of the fire's intensity can be obtained by feeling the walls, doors, windows, and roof. Hot spots on walls and ceilings indicate the location of the fire or the path of the hot gases. A hot spot on the roof of a one-story building indicates the fire to be directly beneath it. A hot spot on the floor of a multistoried structure shows the line of travel of hot gases on the floor below.

e. Danger of Explosions. In planning the method of attacking a fire, the danger of an explosion when fresh air is admitted must be considered. Explosions occurring when fresh air is admitted to a smoldering fire are caused by rapid combustion of heated materials, inflammable gases, or both. Improper ventilation procedure generally leads to explosion hazards. If the opening made for ventilation permits fresh air to enter before the outward draft of fuel gases begins, an explosion may result. Openings should always be made above the seat of the fire to avoid forcing a draft of fresh air into the fuel gases still trapped inside the building. Openings made near the fire which permit large quantities of fresh air to become mixed with fuel gases before ignition occurs are dangerous.

34. Providing Fire Protection

Since fire can be expected to spread as soon as an opening is made, adequate protection must be provided in advance at points of entrance and exposures to other buildings. Enough charged hose lines must be advanced to extinguish the fire and provide an adequate stand-by reserve.

a. Advancing Charged Lines to Points of Entrance. A combination nozzle providing either vapor or a straight stream should be used. The vapor stream is useful in clearing remaining gases and laying a curtain to protect fire fighters from the intense heat. Since carbon dioxide, carbon monoxide, and nitrous fumes are soluble, this water-vapor curtain dissolves and carries down much of the gas ahead of the fire fighters. The stand-by hose should be brought into use only if the fire spreads as a result of an increased oxygen supply.

b. Protecting Exposures. Before the burning building is opened, protective stand-by lines are advanced to other buildings that may be endangered if the fire spreads. (See fig. 78.) These lines are charged and ready but not used until actually required. Some of these lines are advanced over roofs and perhaps inside adjoining buildings; others

are laid to upper floors of the burning building if the fire has not yet reached them.

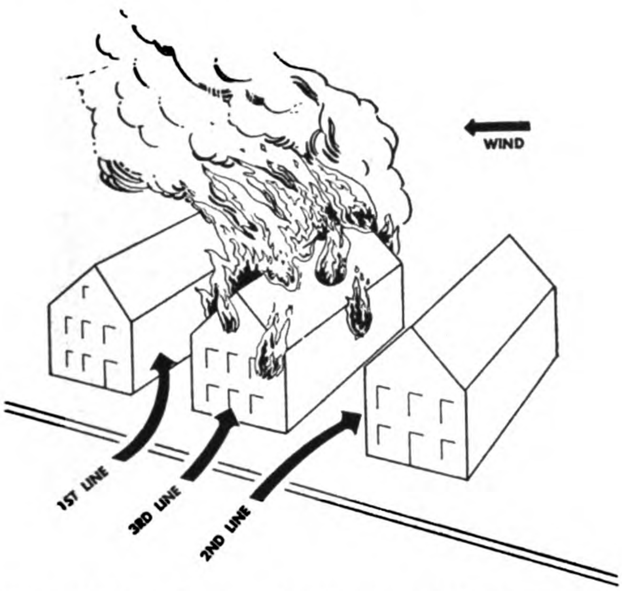


Figure 78. Hose lines are laid in order which gives greatest protection to exposed buildings.

35. Ventilation Procedure

a. PRECAUTIONS. Precautions for safety of fire fighters are considered first in ventilating procedure. Fire fighters who take unnecessary risks not only endanger their own lives but may also handicap the department by becoming incapacitated before the fire is extinguished.

(1) *Masks and oxygen breathing apparatus.* Air containing less than 15 percent oxygen will not sustain life, and that containing less than 17 percent oxygen prevents fire fighters from working efficiently. Carbon monoxide and nitrous fumes in the smallest amounts may be fatal. Fresh-air masks or self-contained oxygen breathing equipment are used where oxygen deficiencies are suspected; all-service gas masks or oxygen breathing apparatus protect against toxic gases.

(2) *Rope.* Rope strung from the entrance to smoke-filled areas permits the fire fighter to retrace his steps.

(3) *Water vapor.* Fog-nozzle streams should be used in approaching the burning area because they absorb and settle combustion gases and disperse smoke.

b. REQUIREMENTS. After the situation at the fire has been evaluated, the building is opened to permit hot gases and smoke to escape and to extinguish the fire in the shortest possible time. The ventilation must meet the following requirements:

(1) Clear the building of smoke and gases.

(2) Prevent further spread of fire.

(3) Minimize smoke damage.

(4) Permit extinguishment with least amount of water possible.

c. VERTICAL VENTILATION. If the internal ventilation of a closed building permits smoke and gas to move to the uppermost level, an opening at the highest level permits them to escape to the atmosphere. This procedure is vertical ventilation. The exit opening is generally made in the roof. The following procedures are important:

(1) Check condition of roof supports to insure that they have not been burned away or weakened to a point where they may fail under the weight of the fire fighters.

(2) Plan a means of escape for fire fighters from roof in case of trouble.

(3) Use any available natural openings such as scuttle holes, penthouses, and skylights if they are properly located.

(4) Do not permit hot combustible gases to pass inflammable materials which are already heated. Fresh air may enter the opening before the outward current is established, starting a new fire at the roof.

(5) Be sure roof openings are extended down through the room ceiling.

(6) Make openings large enough to provide quick exit for smoke and gases.

(7) Work on windward side of openings, keeping in mind the heat, explosive characteristics, and toxic effects of escaping gases.

d. CROSS VENTILATION. If smoke and gases have not reached the uppermost level, cross ventilation may be used to clear the building, one floor at a time. This method requires more care than vertical ventilation because large vertical shafts such as open stairwells may allow downward drafts of fresh air to reach an area not yet opened, causing an explosion. Natural outside openings must be available on each floor level.

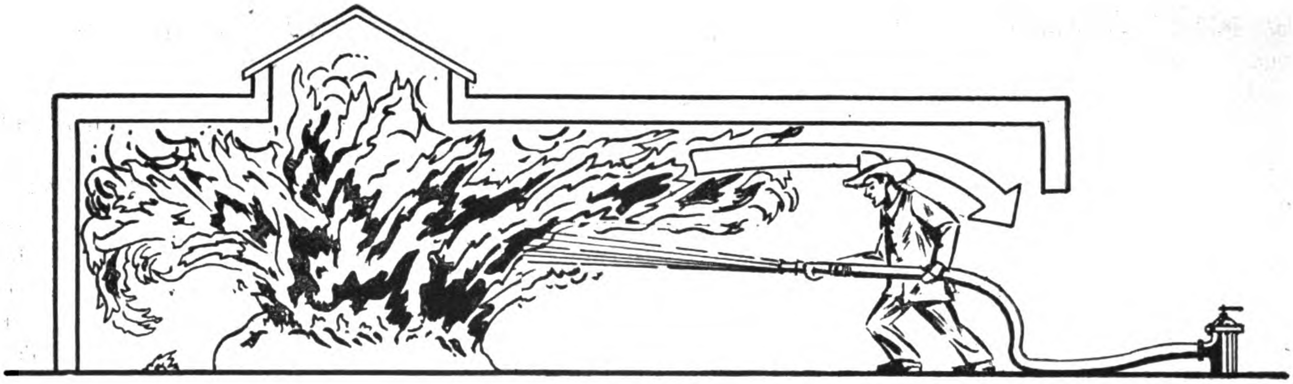
(1) Open windows on leeward side first; then open windows on the windward side.

(2) If windows are check-rail types, open the upper half on the leeward side and the lower half on the windward side.

(3) After one floor is clear, ventilate the next floor in the same way or into the one already cleared.

(4) Do not make openings below the level of the fire.

(5) If opening is made at same level as fire, have hose lines standing by for immediate use.



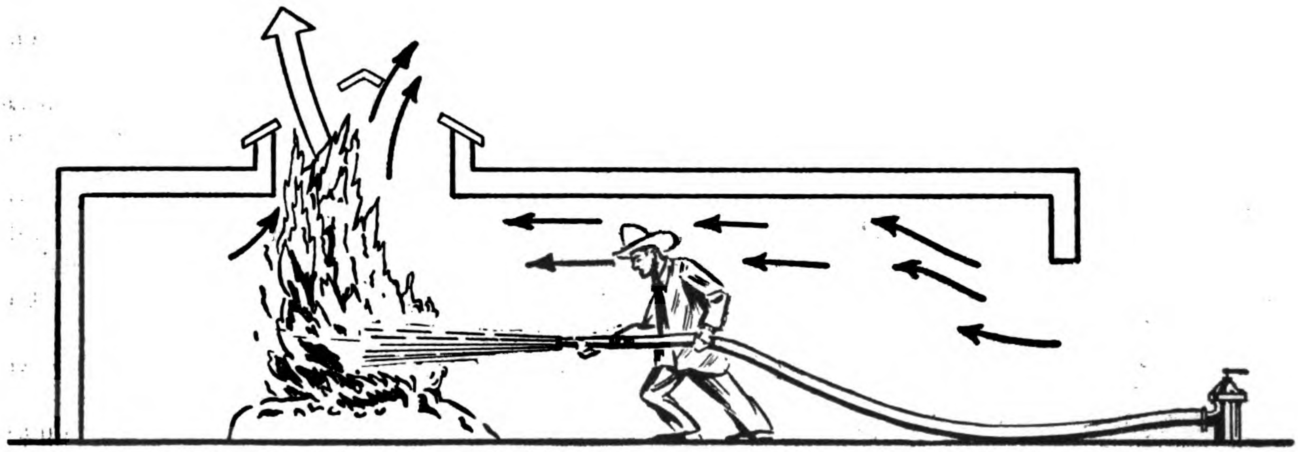


Figure 79. Opening for ventilation must be made before entering.

e. CHECKING RESULTS. Before hose men are directed to proceed with extinguishment, checks must be made to insure that removal of heat, smoke, and gases has been sufficient to permit entering the building. The intense draft set up at the exit opening draws in the cool outside air through every possible crack or opening, cooling the interior quickly. When the flow of smoke and gases from the exit opening cools or ceases altogether, the building probably is ready for entry.

36. Fire Extinguishment

After precautions have been taken against the spread of fire and the opening has been made for ventilation, the next step is reaching and extinguishing the fire. Other openings are made as near the fire as possible, with charged hose lines held in readiness. These openings should never be below the base of the fire. (See fig. 79.)

a. LOCATING BASE OF FIRE. In proceeding through smoke-filled rooms to locate the base of fire, fire fighters advance behind a water-vapor curtain which tends to drive the smoke ahead of them. Following the heat and smoke toward their point of greatest density is the best guide; feeling walls and fixtures and observing currents are also helpful.

b. PERSONAL PROTECTION. Fire fighters must take the same protective measures during the extinguishment process as described for ventilating procedure. (See par. 35.)

APPENDIX

REFERENCES

Books, manuals, and maps listed below should be obtained for reference and use by the fire department. (See par. 1.68, TM 5-600; and AR 310-200.)

Map of post.

Post standing orders.

Fire Department rules and regulations.

Army Regulations.

TM 5-315, Fire Protection by Troop Organizations in Theaters of Operation.

Oklahoma A & M textbooks on Fire Fighting, College Book Store, Stillwater, Oklahoma.

Crosby Fiske Forster, Handbook on Fire Protection, National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts.

Fred Sheppard, Fire Chief's Handbook, Case-Sheppard-Mann Publishing Co., 24 W 40th Street, New York City.

Manufacturers' equipment manuals.

Publications of National Board of Fire Underwriters, 85 John Street, New York City.

Publications of National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts.

Lloyd Layman, Fundamentals of Firefighting Tactics, McGruder Publishing Co, Parkersburg, W Virginia.

State Fire School textbooks.

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